# DISCOVERING

# CD-I

By

ERIC MILLER & WALDEN MILLER

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&

WALDEN MILLER

MICROWARE SYSTEMS CORPORATION

Des Moines

**DISCOVERING CD-I**

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*—Eric Miller*

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*—Walden Miller*

♦ ♦ ♦

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# DISCOVERING CD-I

## Authors' Notes

Writing a book about any new technology is extremely difficult. Especially one that is changing as fast as the world of optical recording. None the less, it is important to try.

As authors, we hope to provide a snapshot of the world as it exists today, so that people not immersed in the evolution of technology can share the vision of where it is going.

In the time since this book was started, several new technologies have been introduced. Some have virtually disappeared. Some merely changed their names. Potential manufacturers of CD-I players are added to the roster every month. Studios for publishing titles are also growing rapidly. The world is really gearing up for the launch.

A year or two from now, we will know a lot more about how consumers will actually deal with interactive TV. Until then, we can only guess. That's what makes this all so much fun.

Eric Miller & Walden Miller
November 1991

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# DISCOVERING CD-I

## Foreword

We stand at the threshold of a revolution in how ordinary people can participate in, and benefit from, the Information Age. The Compact Disc-Interactive system will be the first example of interactive, multimedia technology to be widely deployed in homes, schools and businesses.

CD-I is only the beginning; there will be other related and derivative technologies in the future. Some of these may be based upon HDTV, wideband telecommunications, etc. Because of its status as the launch platform for the mass-market multimedia technology, CD-I will provide valuable experience, stimulate further technical development, and provide a solid economic base to accelerate the evolution and revolution of this exciting, new technology.

Therefore, CD-I should be clearly understood by anyone interested in interactive multimedia technology. Yet to some extent, CD-I has been a mystery for many. This is partly due to the fact that it is a Philips/Sony private industrial standard as opposed to a public domain standard. This is often the case with consumer electronics products (VHS, audio cassettes and DAT are other examples). This seems strange and perhaps even restrictive to those within the computer industry. Existing technical documentation is quite complex and offers no practical "how to" information.

Further compounding the problem, CD-I incorporates new hardware and software elements unfamiliar to even many technically knowl-

edgeable people. These innovations are the reason such a high-capability system can be produced and sold for a modest retail price. This troubles some people who prefer that multimedia evolve from existing standards in the computer world because they have economic or technical interests within the status quo. These people often fail to understand three crucial factors: first, existing computer technology is virtually impossible for ordinary people to understand and use; second, if additional components are added to computers to give them multimedia capabilities roughly comparable to CD-I they become far more expensive; and third, audio and video are real time and thus need an effective real-time software environment.

This type of friction is not unusual when new technology threatens established interests. In this case, a particular problem has been lack of sufficient information about CD-I by potential users to compare and reach objective conclusions.

Thus, the value of this book is that it provides an easily understandable and concise explanation of CD-I, while also providing an overview of application, title development and CD-I studio requirements and operations. The book is written from the perspective of authors and an organization that have played a key role in virtually every step in CD-I development over the last five years, from early R&D and specification efforts to actual commercial applications. The experiences and knowledge the authors share are invaluable to anyone interested in CD-I or other related technologies.

It is impossible to predict today where interactive multimedia will go and the impact it will have, but as the first real, low-cost, mass market platform, CD-I will surely be counted in the future as a crucial milestone.

Ken Kaplan
President, Microware Systems Corporation

♦ ♦ ♦

# DISCOVERING CD-I

## Introduction

During the past two decades, we have witnessed a virtual revolution in consumer electronics technology. More than ever before, state-of-the-art research is being incorporated into everyday household appliances. Compact Disc-Interactive is the latest example of this process.

Quite often, these advances are met by reluctance on the part of professionals until they see the new technology in use. This hesitation is often based on a lack of information concerning the technology itself.

This book is an attempt to provide that sort of information to professionals preparing to enter the CD-I marketplace. It not only defines CD-I's place in the media world, but also guides you through the decision process of entering the CD-I market. Detailed examples are provided illustrating the use of CD-I in the home as well as in business and educational environments.

Compact Disc-Interactive is indeed a new medium, but it is based on sound technology of the past. It may not be appropriate for every use; however, until its capabilities are understood, no real decision can be made concerning its usefulness for any specific purpose.

Some of the questions involved in this decision process are:

- What is CD-I? What are its capabilities?
- Is this the right medium for my needs?
- How much will it cost me to get up and running?
- What CD-I industry services are available now? Are more in the works?
- Does my business need a full Research and Development staff to produce CD-I titles?

To answer these questions, this book provides both an overview of the CD-I industry as it now exists and numerous specific examples of CD-I titles. While admittedly not comprehensive, the example titles provide you with a glimpse of the range and variety of CD-I's communication abilities.

A complete technical overview of the design and production process is also presented. This can be especially useful if you must determine how much of the design and production process can be done in-house and how much must be contracted out. To assist you in your cost analysis, we have provided a variety of production scenarios from small-scale to large-scale production facilities.

Finally, we try to put all of this information into context, weighing the media considerations with the economic and design/production considerations.

Whether you want to use CD-I within your work environment, publish titles for businesses or publish titles for the consumer market, this book will provide valuable information to get you up and running.

## Organization of This Book

This book is divided into four major sections:

### *Getting Into CD-I:*

This section provides a general overview and background of CD-I. It provides numerous examples of how CD-I can be used within a business and as a consumer product. It also discusses the future of CD-I as planned by its creators.

### *A Technical Perspective:*

This section discusses CD-I from a technical viewpoint. An in-depth technical overview of the CD-I player and currently available authoring system software is provided. This section also includes a step-by-step walk-through of the design and production process.

### *Making the Decision:*

This section discusses the economic and development concerns necessary to decide whether CD-I is right for your company. It weighs the costs of in-house development vs. subcontracting for CD-I services, while discussing overall costs of title production.

### *Appendices:*

The first appendix lists the operating system functions supported by CD-RTOS. The second appendix is a reference of the current CD-I software and hardware developers, production studios and pressing plants. A glossary of CD-I terms and an index are also provided.

# GETTING INTO CD-I

♦ ONE ♦

# WHAT IS CD-I ?

## Overview

Compact Disc-Interactive (CD-I) is an electronic communications media. It combines an extensive range of features in a single standardized consumer electronic medium:

- full audio repertoire (hi-fi stereo to monophonic)
- still pictures (and soon, full-motion video)
- animation
- computer graphics
- TV/Video-type special effects
- text/data
- software storage/retrieval

The most distinguishing feature, however, is CD-I's interactivity. This medium allows its user to make choices. The choices can range from how much information is presented to what language the information is presented in; from the ordering of the information to the presentation method (i.e., graphic, textual and/or oral). Because of these built-in choices, the same information can be presented as an education course, a reference "book" and as entertainment—all in the same disc.

## Just an Electronic Component

At its simplest, a basic CD-I player is the latest consumer electronic component for your home audio-video center. It hooks up directly to your television (and if desired, your stereo). Visually, it looks no different than your existing CD player. It has a disc tray, a play button, an eject button and a power button. You can stack it on top of your stereo or VCR.

CD-I players will be sold at consumer electronics stores, right next to the TVs and VCRs. Eventually, most of the standard name brands will be available: Sony, Magnavox, Pioneer, Yamaha, Panasonic, Sharp, Sanyo, etc.

A CD-I player will play your current musical Compact Discs, CD-ROM discs from your computer (given certain software limitations) and, of course, the discs designed for CD-I. The CD-I titles will range from video games to educational courses to reference libraries.

## The Trojan Horse

What makes CD-I so innovative and attractive is the combination of its interactive capabilities and its expandability. Its design is both familiar and unique. A CD-I title is manipulated through a simple remote control similar to the type used for most televisions. This allows its user to explore an unfamiliar CD-I title with a familiar tool now found with televisions, stereo systems and most sophisticated video games.

A CD-I player is also a high-level computer. The basic player may be expanded into a personal computer with disk drives and a keyboard. By connecting your CD-I player to your telephone (via modem), you transform your stereo/TV system into a home information center. The kinds of information available to you will range from standard computer bulletin boards to theater schedules to phone directories to shopping catalogs.

Special CD-I titles will take advantage of these extensions by providing sophisticated software to manipulate and display these sorts of data on your TV screen in a format that you help create.

By marketing the CD-I player as an electronic component of an audio-video system, the twentieth-century dream of getting a computer into every house comes a little closer. It may be our generation's version of the Trojan Horse. Though industry has failed to sell the public a home computer, it just might be able to sneak one into the home disguised as an entertainment system.

# The Language of CD-I

Before launching into a discussion of the development of CD-I and its possible uses, it is necessary to define some key terms. As with every new technology, certain words become defined and redefined in association with the technology. Already, we have used the term "CD-I title" to refer to the CD-I program on a CD-I disc. Some other terms that need clarification are:

***Authoring System***

A set of integrated hardware and software tools that help in the creation of CD-I titles. These range from video frame grabbers that allow the capturing and encoding of video from cameras/tapes/etc. to special tools that allow the designer to create the interactive components of a CD-I title.

***CD-DA (Compact Disc-Digital Audio)***

The optical media format used in standard music compact discs. (Stand-alone system.)

***CD-I (Compact Disc-Interactive)***

This format standardizes the use of video, audio, graphics, and text on an optical disc. It standardizes all programming code under the CD-RTOS operating system. (Stand-alone system.)

***CD-ROM (Compact Disc-Read Only Memory)***

This format is used primarily for data bases and text. This format does not standardize methods for using video, audio or graphics. (Requires computer.)

***CD-ROM XA***
***(Compact Disc-Read Only Memory-Extended Architecture)***

This format provides standards for using audio and video on CD-ROM discs. It also defines a method for using this format on more than one computer platform. (Requires computer.)

***CD-RTOS (Compact Disc Real-Time Operating System)***

This is the computer operating system within each CD-I system. All files/programs on a CD-I disc must conform to CD-RTOS standards.

***CD-TV (Commodore Dynamic-Total Vision)***

This format provides a full range of audio and video; however, this format is exclusive to Commodore Computers. (Stand-alone system.)

***CD-WO (Compact Disc-Write Once)***

This is a special type of optical disc that allows you to write to it one time. Once written, however, the data cannot be erased. Because of the large data capacity of the disc, this is not considered a major problem. A CD-WO disc may be recorded in any format (e.g. CD-I, CD-ROM).

***GREEN BOOK***

The standards for hardware, software and recording format to which all CD-I player and title producers must adhere. The Green Book standards were created through extensive negotiation and research by Philips, Sony, Microware Systems Corporation and other key CD-I developers.

***RED BOOK***

The standards for hardware, software and recording format to which all CD-DA players and disc producers must adhere.

***YELLOW BOOK***

The standards for hardware, software and recording format to which all CD-ROM players and title producers must adhere.

This is enough jargon to get you through these first chapters. A full glossary is provided as an appendix.

# Background of CD-I

As a new technology, CD-I has a unique heritage. It is at once new and innovative and at the same time the inheritor of years of cooperative research and development between some of the electronics industry's finest minds.

CD-I was developed by N.V. Philips, Sony and Microware Systems Corporation. It is the evolutionary result of the digital optical recording process first developed by Philips in the late 1960s. The first consumer product in this field was CD-Digital Audio (CD-DA): the compact disc found in music stores everywhere.

The success of CD-DA is a result of three main factors: the high quality of the digital reproduction, the low cost of disc production and, most importantly, the product standardization achieved during the industry's development stage.

Philips sought an industry consensus on the product standardization before bringing CD-DA to market. This avoided the type of standards competition seen in the VHS/Beta videotape market that cost the consumer millions of dollars and a lot of confusion.

The next major step in digital optical media was CD-ROM (Read-Only Memory). This product was designed for professional and industrial markets. Because of its huge storage capacity and random-access capability, CD-ROM is an excellent choice for many database applications. It is generally used as an add-on to a personal or business computer.

CD-ROM, however, is implemented in a variety of ways by different computer manufacturers and relies entirely on system-dependent software. For example, CD-ROM discs for PC-type systems must be accompanied by MS-DOS specific software. Video and audio standards also vary widely between different computer manufacturers (e.g. VGA, Apple PICT). The bottom line for CD-ROM is that Macintosh CD-ROM discs cannot play on a PC and vice versa.

This lack of uniformity in implementation causes some distinct problems in marketing because CD-ROM does not define any audio or video standard formats. Even so, CD-ROM is finally catching on in some business and educational markets as the availability of CD-ROM drives is popularized.

CD-ROM XA (Extended Architecture) attempts to correct the deficiencies of CD-ROM by defining standard audio and video formats. It also attempts to address the issue of software/hardware compatibility by providing a method for storing applications in a variety of software formats on a single disc. For example, a single application could be stored in Apple, MS-DOS and CD-RTOS formats to ensure that the application could be played by a majority of players. Ultimately, however, CD-ROM XA does not define a single computer format, but leaves it up to the individual title publisher to choose which computer platforms to support and which to ignore.

CD-I is the natural evolution of both CD-DA and CD-ROM. It combines the universal format of CD-DA with the interactive audio/video/text of CD-ROM and CD-ROM XA. It provides publishers and consumers with a single media standard for digitized audio, video and text/data. This universal format ensures that every CD-I player can play every CD-I disc, regardless of the title publisher. The universal format is essential to broad consumer acceptance.

To accomplish this, Philips formed the Green Book Committee to achieve an industry consensus on what standards should be minimally adhered to when mastering titles and manufacturing players. The years of research, discussion and compromise that went into creating the Green Book are an attempt by Philips and the CD-I/electronics/computer industry to duplicate the success of CD-DA.

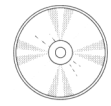
By obtaining the Green Book hardware and software standardization and marketing CD-I as a stand-alone consumer electronics system, the CD-I industry avoids the marketing problems inherent in CD-ROM and looks forward to the success seen with CD-DA.

CD-DA
(Digital Audio)

Stand-Alone System:
Standardized Audio

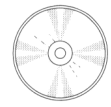
CD-ROM
(Read Only Memory)

Requires Computer:
Non-Standardized Audio
Non-Standardized Video



CD-ROM XA
(Extended Architecture)

Requires Computer:
Standardized Audio
Standardized Video



CD-I
(Interactive)

Stand-Alone System:
Standardized Audio
Standardized Video

**Figure 1:**
**The Evolution of CD-I**

# THE CD-I INDUSTRY

One of the first considerations a business must have when entering a new industry is whether there is a full industry infrastructure in place or whether key services are still in the development stage. For CD-I to be an effective industry, there must be four major infrastructures: CD-I player manufacturers, CD-I authoring system suppliers, CD-I title publishers and CD-I disc pressing plants.

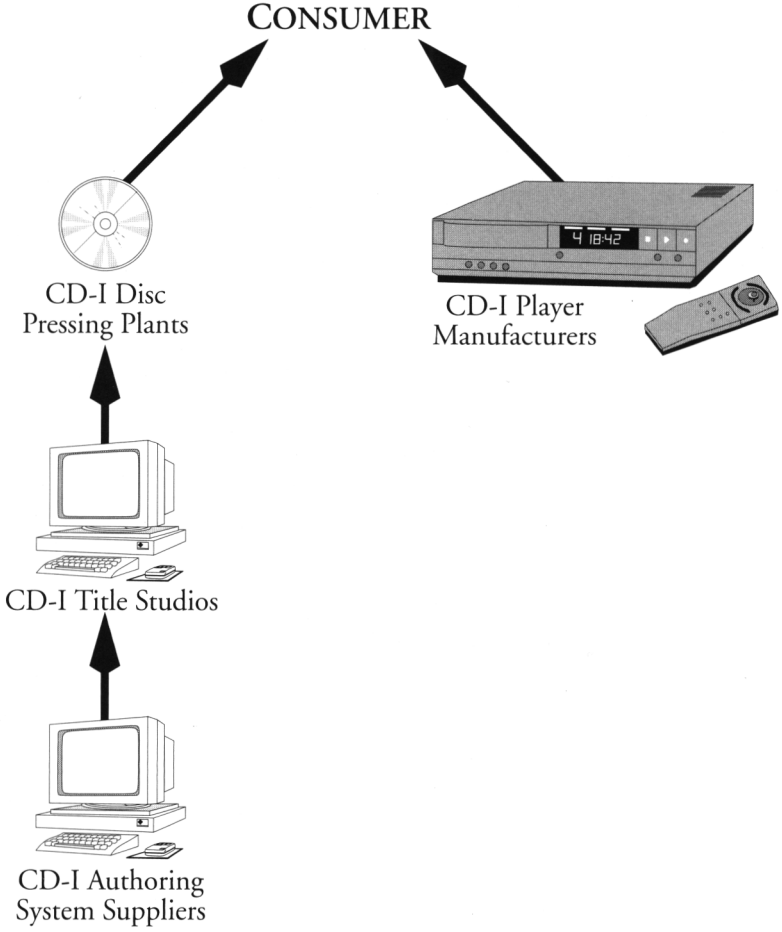



**Figure 2:**
**CD-I Industry Infrastructure**

Through extensive planning and development, all of these industries are currently in place and functioning. The appendices give a listing of these companies and their role in the CD-I industry.

CD-I began development in the early 1980s. Philips collaborated with engineering design teams from Sony and Matsushita, among others, to create the first CD-I hardware standards. These three companies were responsible for developing the dedicated integrated circuitry used in building CD-I players. Philips and Sony then entered into licensing agreements with more than 150 leading electronics manufacturers and publishers. These companies are the foundation of the CD-I industry.

Microware Systems Corporation provided the next major component for the CD-I industry. Contracting through Philips and Sony, Microware developed the main system software for CD-I: the Compact Disc Real-Time Operating System (CD-RTOS). CD-RTOS manages and controls the interactive functions of CD-I and is the basis for all computer extensions to this medium.

CD-RTOS is a version of the OS-9 operating system specifically configured for CD-I. OS-9 enjoys a rich fifteen-year history in the embedded systems and industrial control markets. It is an operating system that has been refined through years of service. CD-RTOS inherits all the labor and support of OS-9, while addressing the new challenges of CD-I.

In other joint ventures, Philips has developed suppliers of hardware and software to create, test and integrate CD-I titles before the mastering and replication process. These companies provide what is known as *authoring system* hardware and software. Most notable here is OptImage Interactive Services Company, the primary supplier in this field.

OptImage is a joint venture between N.V. Philips, Microware Systems Corporation, Sun Microsystems and NCS. It develops and markets authoring systems for studios and other companies interested in title production.

In order to decrease start-up costs for new CD-I title publishers, OptImage has:

- Developed systems that take advantage of currently available hardware and software.
- Provided methods for translating audio and video data into CD-I formats.

For example, "Photoshop Plug-ins" works with Adobe's "Photoshop" video processing software to provide CD-I format images. Likewise, OptImage's "Audio Conversion Utilities" (ACUs) work with Digi-Design's "Sound Tools" to provide CD-I digital audio.

The typical authoring system now consists of a Macintosh front end (Mac II or greater), a 600 megabyte hard drive to simulate the compact disc storage capacity, a professional scanner, software tools for audio and video input/editing, a CD-I emulator, a CD-I player and Ethernet to provide connections to other systems. (A discussion of authoring tools and their use is provided in a later chapter.)

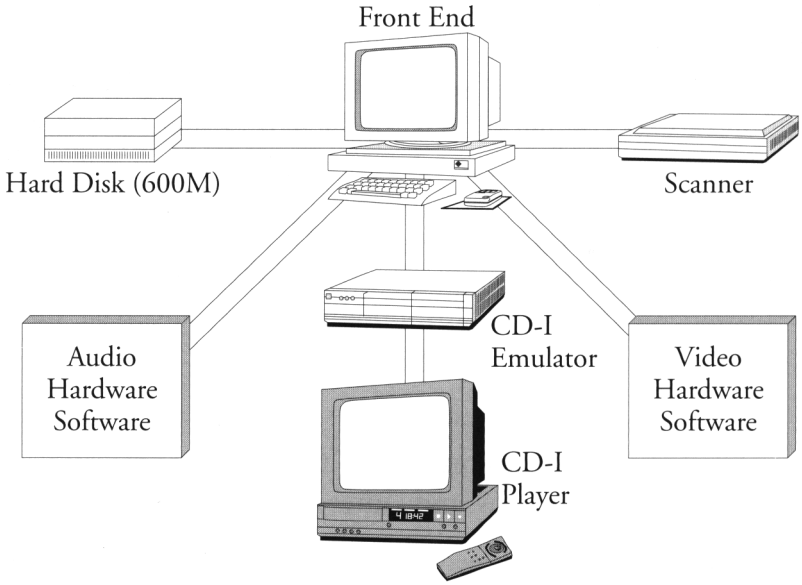



**Figure 3:**
**Typical Authoring System**

The result of OptImage's efforts has been to reduce the authoring system cost from $250,000 for a custom system in 1988 to $25,000 for an off-the-shelf system in 1991.

This decrease in the cost of authoring has allowed a host of new studios to be formed in the past few years. Today, there are more than100 CD-I studios operating around the world, and virtually all of them are preparing for the consumer launch of CD-I.

For companies without the resources to produce their own titles, many of these studios/publishers will provide the necessary technology and expertise. Most notable here is Philips Interactive Media of America (PIMA). It is the primary publisher of CD-I titles in the United States. PIMA has an extensive network of co-producers throughout the country and provides valuable services to smaller companies. Other significant studios/publishers are Microware Systems Corporation, Capital Disc and Interlight.

As more authoring system software becomes available and the CD-I industry becomes better understood, current audio-video studios will provide CD-I services.

Finally, disc mastering and reproduction facilities are widespread. The same facilities used for CD-DA are totally compatible with CD-I. Consequently, any CD pressing plants currently pressing audio discs become instant resources for CD-I.

# THE CD-I MARKET

While we have discussed the history and infrastructure of the CD-I industry, we have yet to examine the potential markets for CD-I. In other words, who is going to buy CD-I?

We believe that CD-I will have as many markets as there are creative applications of CD-I. In the following chapters, we will take a look at a variety of these applications. But for now, let's examine the broad markets and, consequently, who might be interested in publishing titles for these markets.

### Home Consumer Market

This is by far the largest audience. CD-I titles will range from games to travelogues; from how-to's to audio/video entertainment. Publishers will accordingly range from the record industry to the standard publishing industry to the game industry to just about anyone in the information business.

### Business Market

This audience likewise will have a wide variety of interests in CD-I. CD-I will be a great addition to the in-house training tools currently available. It will provide an excellent platform for marketing presentations or any other professional demonstrations. CD-I is well suited for product documentation that could include visual installation instructions as well as the standard manual text.

Every business or agency that has an in-house training department or gives training seminars to its customers or clients will be interested in CD-I. Marketing departments and businesses that invest a lot of time in professional presentations also will be interested in creating titles.

### Educational Market

For every type of classroom, there is a possible CD-I application. Consequently, this audience is limited only by the budgets of the individual

schools. Possible educational CD-I titles could range from interactive language instruction to on-line chemistry labs. Titles could be created for any age level.

Current textbook publishers and educational institutions themselves are perhaps the easiest title producers to point out. However, because the interests of the audience are so broad, almost any publisher could enter this market with the right title.

### Information Market

This use of CD-I overlaps every other market: home, business and education. Easy access to reference materials appeals to almost anyone. The on-line reference materials will include atlases, dictionaries, encyclopedias, almanacs, stock reports, library holdings and almost any database that is available.

The government agencies, businesses and educational institutions that create and maintain these databases and reference materials all will benefit from publishing and updating them in CD-I format.

### Retail Market

Another market that seems to overlap all others is the retail market. Everyone buys things. Using CD-I as a sales tool seems quite appropriate. It would be useful for help in choosing hard-to-find selections, and viewing and purchasing items not locally available. CD-I could be used directly by the consumer or by qualified salespeople assisting customers.

Titles in this field would be produced by the retail companies themselves. The CD-I titles would be used at their existing stores or as an alternative to a retail outlet in areas that cannot support a full retail outlet.

### Why Will People Switch to CD-I?

This is, of course, the bottom line. Why should you or anyone else consider CD-I as a publishing medium? What needs does it meet that are not being met by the present media? Why will the public embrace CD-I?

The only real way to answer those questions is to discuss the strengths and limitations of current communication media and how CD-I addresses those same issues.

♦ TWO ♦

# THE COMMUNICATION PROBLEM

## Media Types and Topics

There is a distinct problem with trying to categorize and discuss the various traditional communications media: almost all media overlap. For example, the line between television-type media and computer/video game media is quite hazy. Laser discs are good examples. Laser discs are ultimately a passive visual media, but when used with a computer system, they seem quite interactive.

Although the following categories are not exhaustive and there is distinct overlapping between them, we will use them as a starting point to discuss the advantages and disadvantages of current communications media:

- Audio Communication: We defined this type as solely audio. It includes speeches, tape recordings, radio, etc.
- Printed Communication: This includes all types of printed material, such as books, magazines, brochures, etc.
- Passive Visual Communication: While printed material is certainly visual, and media such as television is also auditory, we defined this type as media characterized by a video display that requires little or no interaction. Examples of this are television, VCRs, video discs, etc.
- Active Visual Communication: Again, this type of media is capable of audio, but is characterized by a video display that requires interaction by its users. Examples of this media are computers, video game machines, etc.

## Audio Communication

The oldest of these methods is audio. We have told stories for millennia. People listen when people talk. In education, we commonly learn through lectures or talks by knowledgeable professionals. In business, salespeople often will assert that all they need is to actually talk to their customer to make the sale. In politics, campaigns are made or broken by a speaker's oral ability. With the advent of radio and telephone, oral communication was able to reach large audiences across great distances. With tape recordings, audiences were no longer required to attend an event at a certain time, but were freed to listen at their convenience.

Oral communication's strongest feature, as radio salespeople will insist, is the power of the voice. For many people, nothing beats the enjoyment of being read to. It can stir your imagination and emotionally move you. In educational settings, the lecture is used to teach a student an idea through the conviction of the teacher's words. Quite often, hearing an idea can have a much greater effect than reading it because of this conviction. It can also, through repetition, implant an idea or sound in the listener's mind. In this sense, oral communication is ideal for advertisement, subliminal self-help recordings and foreign language acquisition.

Even with our rich oral history, there is very little marketing that is now done strictly on an oral basis. Much of the radio advertising, telephone marketing/sales and tape recordings are now augmented with television or newspaper ads and/or written copy of some sort.

While oral communication's greatest feature is its ability to convey conviction and emotion, its greatest drawback may be found on the flip side of that same feature. Oral communication is very clumsy in dispersing detailed information. It is too easy to misinterpret a speaker without some sort of visual or textual aid. Because of its ability to convince people of an idea, misinterpretations often can compound themselves as they become the basis of further action.

Audience appeal is also problematic for spoken communication (and most other methods of communication). It is quite hard to reach more than a single audience in any given communication. Radio solves this by

providing a station for every taste or a program format that varies throughout the day providing a little bit of everything for everyone. While the media's audience limitation is not debilitating, it is worth noting.

## Printed Communication

By far, one of the most successful communication systems has been printed material. In this media, the power of words that can stir the imagination can be combined with visual and graphic elements to create a powerful impression on the reader. What is lost in dramatic immediacy is gained back in the lasting quality of the printed word. A book or magazine can be used as a reference again and again. They are portable, relatively cheap and don't require batteries. They are easily copied and stored.

The daily newspaper is a vital organ for informing the public. The power of the press is demonstrated by the continual efforts of the various governments in the world to either protect or limit the freedom to print information.

The textbook is the mainstay of the school curriculum. It provides easy access to countless facts, theories and stories. In industry, the instruction/user/technical manual plays much the same role.

In the marketplace, advertising copy is considered indispensable for informing potential customers of the advantages or necessity of using a particular product.

For entertainment and reference, publishing books and magazines is a cheap process, considering the amount of information that is distributed. With the advent of laser printing and desktop publishing, it has become even cheaper to create a do-it-yourself printing station. Now professional-looking documents can be tailor-made for very small audiences at a relatively low price.

One major drawback of the print media, however, is that it is very hard to write for more than one audience in a single document. Consequently, materials must be targeted at specific educational or demographic sectors

of the population. International communications must be printed in different languages and sometimes different formats, depending on the accepted norms of the culture.

Another drawback is that printed material is viewed as disposable. Because of the paper quality, paperback books are relatively flimsy and are often discarded after a single reading. Newspapers and magazines are out of date as soon as they are read. According to recent studies, 18% of our current landfills is newspaper and 50% is paper. This environmental concern goes hand-in-hand with the fact that the amount of paper used is depleting our forest resources.

Finally, books are bulky. This is not only a concern for the average reader who must find shelf space for the home library; the necessary resources required by a city or university to establish and maintain an adequate library is staggering.

## Passive Visual Communication

The easiest distinction to make within visual media is whether you are required to interact with it. *Passive* media require nothing more than changing a channel or inserting a videotape and pressing the play button. *Active* media require you to make choices. They will do little or nothing without your request. Regardless of the type, visual communication is one of the most powerful forces in today's world.

We are now a visual culture. We want something to look at. You only have to look at the success of MTV to realize how easily visual entertainment can eclipse the "simple" audio and print worlds.

We are a world with television.

Through television, we can be instantly linked to any event occurring in the world. With cable and satellite TV, we have access to hundreds of programs originating from studios throughout the world. With videotapes, we have literally thousands of viewing choices.

The success of the videotape is a remarkable testimony to our love affair with the video format. It is used primarily for entertainment. It is also a powerful marketing tool for salespeople who need to persuade customers of their clout, integrity and resources. Educationally, the do-it-yourself tape is extremely valuable. You can learn most manual tasks easily and without the embarrassment of asking "stupid" questions over and over. You just need to rewind and replay.

There are some distinct drawbacks to videotapes, however. Like text, only one audience may be addressed at a time. Television's answer to this is to provide fare that the majority of the viewers want. It panders to the lowest common denominator. Videotape is more selective in that it targets many small audiences and provides specific tapes for specific audiences. However, it is not able to easily provide information or entertainment for a variety of skill levels, education levels or aesthetic tastes on a single tape.

By their very nature, television and videotape are essentially linear media. This is both a boon and bane to communication depending on its use. For entertainment, the linear quality provides a solid platform for movies. For reference or other uses, videotape's linear nature is definitely a hinderance. When you want to find a specific item on a tape, there is no inherent indexing that is provided by the media. You must rewind and/or fast-forward until the desired section of tape is found. While some players provide a tape-marking system, videotape still is less than optimal for a reference media.

Additionally, there is no international standard for videotape. Or perhaps one might say there are two standards: PAL and NTSC. Consequently, international video publications must be released in different formats as well as different languages.

Other drawbacks of videotape include its flimsy quality, its relatively poor picture quality and its bulkiness.

The laser disc overcomes many of these drawbacks as a medium. It also has penetrated the home and business markets. While not enjoying the success of videotape, the laser disc has devout believers.

The laser disc format is a 12-inch disc that contains up to one hour of full-motion video or 50,000 video still frames. When used in stand-alone systems, laser discs provide a higher-quality movie/entertainment alternative to VCR tapes. They also provide a much faster access time; moving from the beginning to the end of a disc takes seconds, instead of several minutes.

Laser discs are most commonly found in the private sector. In business, however, laser discs can be combined with computer systems to provide full-motion video in training situations or marketing presentations.

Overall, the passive nature of television, videotape and laser discs reflects their linear quality. They provide information sequentially. There is no cross-referencing capability or internal indexing to assist in searching. At best, a viewer can rewind a tape or disc and review the information.

**Active Visual Communication**

The newest entry into the communication field is active visual communication. The basis for active video is the computer. Computers, like television, have changed our world irrevocably. They are everywhere: visibly, in every office and many homes as personal computers, game machines and business workstations; and invisibly, in televisions, stereos, bank machines, cash registers and almost any electronic device manufactured today.

The element of choice is the main factor that distinguishes the computer from passive visual media. A viewer can make choices during a presentation. These choices are provided in a variety of formats; for example:

- Would you like more information on retro-widgets? (Yes/No)__
- Press F1 to see another view. Press F2 to exit.

The strength of computers is their ability to manipulate and process large quantities of the requested information easily and quickly. This not only includes numerical databases, but words, sounds and pictures. This ability is based on their non-linear nature. A sophisticated indexing system keeps track of all the information on a disc at any given time. This allows

a computer to directly access information regardless of its physical position on a disk, instead of sequentially searching through the data until the desired information is found.

The primary limitations for manipulating information seem to be the speed of access (i.e., how fast one can get the information), the speed of processing that information (i.e., how fast it can be made useful) and the quantity of information that can be stored easily on a given medium.

The speed limitations are being assaulted by almost every chip manufacturer and systems programmer. As chips become faster and more powerful, operating systems and supporting software can be optimized to take advantage of the new chips' designs. This translates into faster access and powerful software tools for processing.

There are a wide variety of physical storage formats used by computers. Floppy disks, at present, can hold up to two megabytes of information. They are extremely portable, although slow. Hard disks have the advantage of speed and storage size, but they are not meant to be portable. Optical discs have the advantages of portability, storage size and low price.

A compact disc can hold 600 megabytes of data of various information types: text, audio, video and compiled code. This translates into more than 300,000 printed pages of text, up to 19 hours of audio or an hour of full-motion video.

A perceptual problem with digital information is that it generally is thought of as out of the common person's reach. The computer phobia is well documented. Even as computers become more prevalent in our lives, the personal barriers rise higher and higher. The futuristic dream of a personal computer in every home seems to have turned into a topic merely for the realm of fiction.

In all fairness, there is one computer system that has made great in roads in the consumer market. Capitalizing on the popularity of the video arcade in the late 1970s, a small number of companies have made fortunes selling home video games. Chief among these companies is Nintendo. Through 1990, it claims to have sold 60 million game machines world-

wide. And while its primary targeted audience is 10- to 18-year-olds, adults form a growing percentage of its actual user base.

One of the major attractions to video games is the variety of skill levels they provide in a single game. In other words, the game essentially adjusts to the audience. This cannot be said for any other media that we have examined.

The major drawbacks to the Nintendo system (and other game systems) are the lack of realism (low resolution animation at best) and the fact that games are just that, games. These systems will not provide movies, encyclopedias, music videos or any other choices essential to a complete home entertainment system. In addition, the computer that drives these systems will remain completely inaccessible to the user, keeping the game machine only a game machine.

This is the promise of CD-I. CD-I overcomes the standardization problems of CD-ROM and video discs by providing a standard software and publishing format, while disguising itself as a stereo component. It can provide the excitement and challenge of adjusting to its audience, while providing the wide range of options available from audio, print and visual media. Finally, the computer that is the heart of CD-I will be accessible as a computer.

Consequently, CD-I seems the most promising of all media to this point. It can potentially access the most information. It can combine the best qualities of audio and video media in ways in which the world has not yet dreamed.

# MEDIA TOPICS

It is not only in our interest to examine the individual types of media, but also how these media work in four major areas of information communication: education, entertainment, reference and commerce. Like the four types of media, these communications topics often overlap.

## Education

Education uses a variety of methods to teach students. The two most common are the lecture and the textbook. Recent educational theorists, however, insist that discussion and interaction between students and teachers and between the students themselves is more instrumental in the learning process than the historical lecture method. The movement toward discussion has led to an insistence on relevancy in the classroom. Hands-on experience and case studies have replaced many purely theoretical educational frameworks.

New classrooms use lectures, texts, films and presentations as starting points for discussion in the search for understanding, not as the final say. Consequently, videotapes and computers have found their way into classrooms of all levels, from kindergarten through graduate school.

One of the first companies to recognize the importance of this market was Apple Computers. Apple provided substantial discounts to school systems and students throughout America. The theory was that if students use Apple computers in school, they would graduate and demand the same computers in the home and workplace. To a certain extent, this version of the Trojan Horse has worked. Apple computers have certainly made great inroads in both home and business environments.

But the real impact of Apple's strategy is seen in the way students learn. The rise of hands-on learning and interactive hyper-media has challenged the standard lecture/textbook mode and changed the face of modern education.

Corporate training also has moved in this direction. Training on the job consists of workshops and hands-on education. Computers, videotapes

and roundtable discussions are now common in virtually all training centers.

Another area of the educational market is seen in the use of self-help/instructional videotapes. For example, when renting a floor sander to do some remodeling, a videotape on the use and maintenance of the floor sander is commonly provided. The videotape also might include recommendations for floor-finishing techniques, such as the use of stains and polyurethanes. Likewise, when buying a water-filtration system, an installation video is included. These tapes do not replace written instruction but instead provide very helpful visual clues on operation and installation procedures that are inadequately provided by written instruction.

**Entertainment**

The success of video entertainment has made a significant impact on the entertainment industry. MTV and music videos, for example, have created a new expectation for the use of video entertainment. Computers and game players, on the other hand, have raised the sophistication level of the public and consequently also have raised the general entertainment expectations of the public. Both video- and computer-based entertainment hold a fascinating grip on our culture's life styles.

For example, the VCR industry has changed the way we spend our leisure time. It is now common to pick up a movie with your groceries for an evening of viewing. People have become sensitized to video *release dates* of current movies to the extent that many newspapers run columns reviewing videos, listing release dates and cataloguing the most popular rentals.

Video games have also been accepted into mainstream life. The success of Nintendo along with the numerous available computer games is phenomenal.

The shift to video entertainment highlights a trend toward making the television the center of the home entertainment system.

Paralleling the success of the VCR is CD-Digital Audio (the music compact disc). Within a decade, the compact disc has driven the vinyl LP completely out of the market.

The success of the compact disc is important for two reasons. First, it shows the importance of format and quality standardization in consumer acceptance. Second, it demonstrates the willingness, as a culture, to adopt new technologies very rapidly. The acceptance is especially noteworthy when one considers the initial cost of a player was much higher than today's relatively low prices for a CD player.

This is not to say that video entertainment will eclipse all other forms of entertainment. For example, while many futurists have promised the world computerized *books* and on-line libraries, the fact is people like having a solid book in their hands. We as a culture will not voluntarily replace the hard-copy book. But that does not mean there is not a specialty market for books on tape, books on disc or books accessed through on-line systems. There is ample room and need for both styles of entertainment.

## Reference

One of the problems with the communications revolution of the past few decades has been the availability of and access to the incredible amount of information that is being catalogued. Libraries become bigger and bigger, but access to the information remains the same. Trying to find the information you know is out there can be incredibly frustrating. Consequently, card catalogues have given way to computerized databases. But even so, the creation and updating of these databases still lags behind the proliferation of information.

What is needed is an extensive effort to cross-reference the current libraries with an ongoing program of timely updates.

Some corporations and certain government agencies do this routinely as commerce depends on up-to-date economic and demographic databases. The access to these information systems is critical to modern business.

CD-ROM has filled this niche well in both the private and public sectors. The storage capacity of compact discs combined with the access speed and searching abilities of modern computing has gone a long way toward providing us with information in a quick and relevant fashion.

National bulletin board services provide much the same services to a demanding public. Not only are services such as daily stock reports and economic indicators provided, but simple want-ads bulletin boards show the desire for national networking of information.

What still remains as a major hurdle in accessing reference materials is the sheer size and cost of creating a private library. A 30+ volume encyclopedia is a good example. Its size prevents it from being portable, while its cost prevents it from being a common household item. Not only is it quickly out-of date, but supplementing an encyclopedia set with the yearly update volume merely causes frustration in finding current information.

Placing encyclopedias and other common reference materials such as dictionaries, almanacs, atlases, etc., on compact disc will go a long way in solving the problems of cost, portability and updates. Using multimedia systems for reference materials also will enhance the original material, making the "documents" even more meaningful.

## Commerce

While we have discussed many of the education, entertainment and reference media products, the use of media in the sales and marketing of products also is worth noting.

For advertising, print is by far the most common medium. This ranges from newspaper copy to junk mail to the Yellow Pages to product brochures. Like books, this advertising medium will not go away voluntarily. Nor should it. The ability to have something in print in your hand is important not only as a reference but as a guarantee of business promises and delivery. Print can provide very detailed images and technical information not easily conveyed by other media.

But marketing also uses a variety of other media to sell products. Videotape presentations are becoming common throughout our industries. Videos are used to show potential customers product lines, office and plant layouts, along with the initial training and installation procedures for new products. Videos have an edge on print in the sense that pictures can easily show what words have to struggle for: a process. This dynamic quality can often play a pivotal role in differentiating one product from another. Pictures have a high impact on memory recall. Once you have seen a procedure or a good presentation, you have a much better idea of what a product is and what it can do.

Recently, we also have seen the use of videotapes and interactive video for point-of-information and point-of-sale marketing displays. Some department stores have installed interactive video systems to assist customers in finding their way through the store to the appropriate department, alerting customers to current sales and marketing new items.

For example, one chain of shoe stores installed a system that displays shoes that are not available at the local store but can be ordered. Even though the salespeople initially resisted the idea that this type of information system could increase sales (i.e., the salespeople believed that they could sell better than any machine), they eventually found the system to be very useful for meeting the needs of the customer. As it turned out in this case, the salespeople became experts at browsing through this video warehouse *for* the customers. In other words, they retained the role of salespeople displaying their wares.

Similarly, point-of-sale markets could be equally dynamic. The *video mall* is potentially a great boon to remote customers. Like the catalogue sales industry, the idea is to generate sales in areas that cannot support a full retail store. Instead of a store, a retail center would require only an interactive video/computer sales system: a booth with several terminals representing retail outlets that customers could *browse* through. Selections made on the system would be paid for with a credit card. Delivery would be made directly to your home.

Both point-of-information and point-of-sale markets are new and growing; they have great potential.

♦ THREE ♦

# THE COMMUNICATION SOLUTION

## CD-I Examples

The best way to talk about CD-I's potential as a medium in the various communication arenas is to present example titles that are currently being produced and possible titles that no doubt will be produced.

### Training and Education Titles

In major corporations, enormous resources are spent training and retraining personnel. Various methods are used, including classroom hands-on training, self-paced instructional manuals and introductory videos. CD-I is especially suited for these types of needs.

For example, imagine a new employee. She is given a stack of manuals, a terminal and a workspace. She is told that later in the week she must attend a series of training courses to get her up to speed. In the meantime, she should read the manuals and try a few of the self-paced guides. She must wait for the courses because of the scheduling of the trainers and classrooms involved.

Now, imagine the same scenario with a CD-I title that not only provides basic orientation to the corporation but anticipates both routine questions that are asked in orientation and also many of the more obscure ones. The information in the title is organized so that the questions can be answered in a cursory manner or, if more detail is needed, they can be answered in a depth that is usually reserved for face-to-face questioning.

The interface could be handled in many ways: textual with accompanying printed documentation, visual with still images and narration or any

combination of text, animation, still imagery and narration. These graphic elements could range from a "you are here" map of the building with an interactive "how to get from A to B" guide, to a graphic orientation of how an individual's job fits into the big picture, including product process charts and corporate organizational charts.

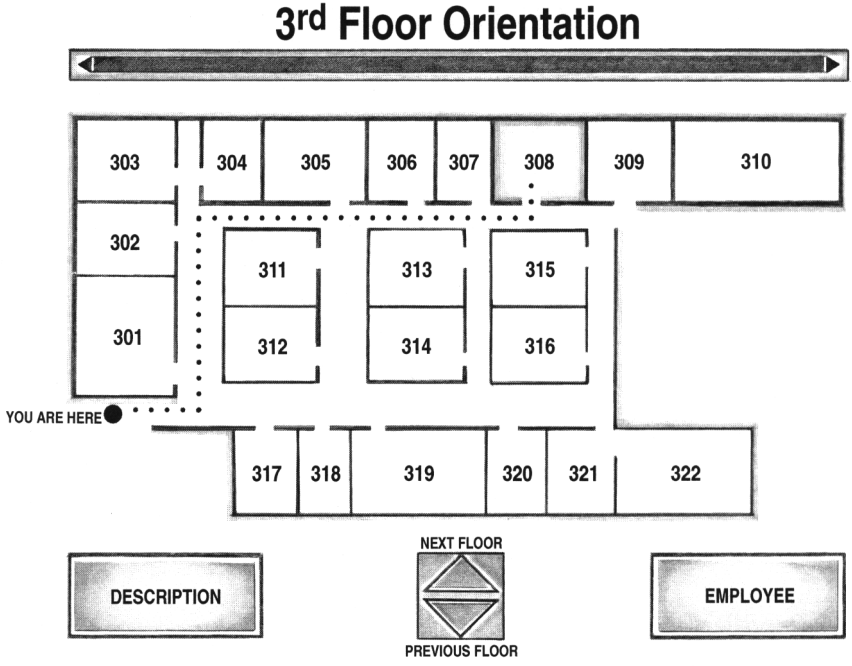



**Figure 4:**
**CD-I Training Title: Office Orientation**

This title would eventually be used by the employee as a resource, not solely as a learning tool. Feedback from employees would *create* the next generation of titles for the company. Experience will provide the information that is hard to put a finger on, but is needed the most.

This is one of the strengths of CD-I: the layering of information in an accessible media. CD-I does not replace hands-on training of classroom workshops; however, when used in conjunction with the classroom, it be-

comes a powerful educational tool and frees up valuable training time for more important issues. It does not replace reference books or experts, but an amazing amount of information can be retrieved quickly through CD-I. And a title's organization can be very non-linear and intuitive or very hierarchically structured, thus mirroring the user's preferences.

Another example might be to record the process and skills necessary to do a certain task currently understood by only a few individuals. Because the repository of knowledge exists in only a few hands (or heads), recording the information could provide a sure back-up in case of emergency.

This type of title would include all documentation on the subject. It would be cross-referenced and indexed according to the needs of the user. Simple overviews would give way to deeper and deeper discussions. The title could include recorded lectures by experts in the field, with appropriate graphic and textual supplements. This frees up time for the experts in that they do not need to answer or be on call for routine questions. They can cut down the time spent bringing new employees up to speed on the subject. In companies that are not located in a single geographic area, this could also decentralize the expertise and cut back on long-distance travel.

## Educating the Public

In the same manner that self-help videotapes have become a real boon to the instructional industry, CD-I could have major impact. One of CD-I's more unique features allows a single title to be encoded in various languages so that the user need only choose the *native* language desired and begin.

This overcomes one of the biggest problems seen in all other media: different products for different countries. A single disc could be used for all European countries. The simplest example that comes to mind would be a language instruction title for travelers.

On the very first screen, the title would ask for the native language on which to base the instruction. A traveler from the United States, for example, would generally choose English. The next screen could allow you

to choose the type of method for instruction or use. For example, you could ask for instruction by topics, such as a trip to the restaurant, bank or grocery store. From there one could choose items for translation (menu items, currency rates, household supplies) or for common questions/sentences (asking for a waiter, "where is the bathroom?", etc.) In either case, the foreign word or phrase could appear in a written form and be pronounced aloud. As a person travelled, different languages could be accessed, all with the same disc.

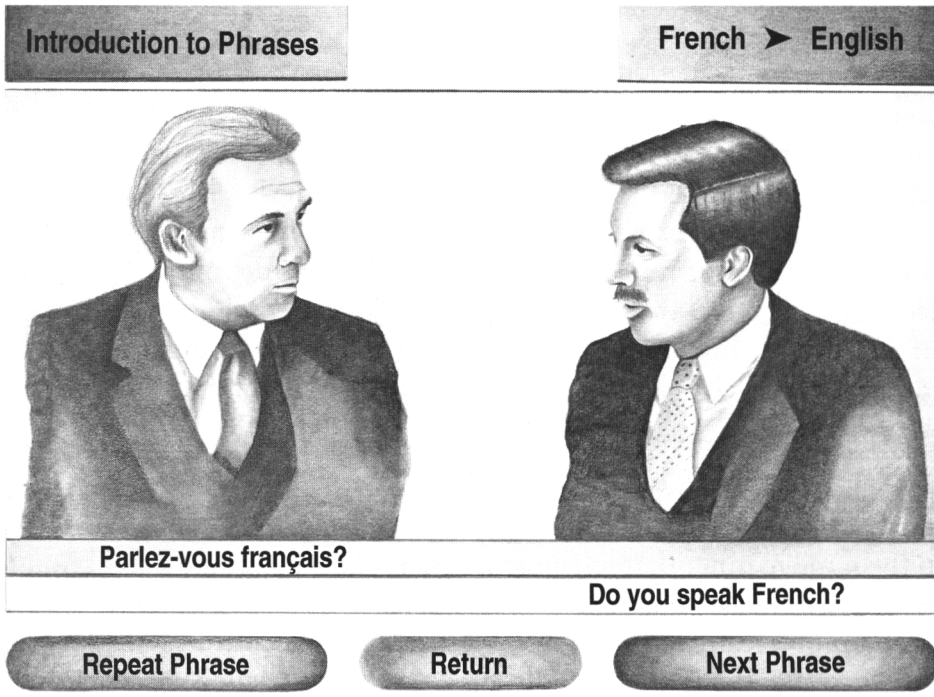



**Figure 5:**
**CD-I Language Training Title**

This type of program is dependent on portable, battery-operated, hand-held CD-I players. Like the portable CD-DA players that arrived soon after the home console models, the portable CD-I player will be available soon after the initial release of CD-I.

Other educational titles might include supplements to textbooks that could show complicated processes in animation where current textbooks can only show a single image at a time. Graded exercises could be designed to allow students to proceed to the next level only after mastering the current assignment. Cross-references to both the textbook and supplementary readings could assist students in seeing problems in their assignments and lead them to further information outside of the standard text.

Titles such as these are currently being developed in *hyper-media*, a name given any number of interactive computer programs. Their success is a testimony to the desire for interactive instruction despite high up-front costs for computer equipment and computer instruction.

## Interactive Entertainment

While not wanting to beat a dead horse, the success of video games demonstrates the promise for interactive CD-I games.

The desire to play interactive games is already established. It is up to CD-I designers to create titles that fully use CD-I's features. One such example is "Cartoon Jukebox" (published by Philips Interactive Media of America).

This title combines popular children's songs, cartoons and games. While the song is played, a cartoon is shown. When the cartoon is over, children can change the colors of the main elements/characters of the cartoon by clicking on a color and then the cartoon. After the elements are colored, the children can listen to the song again with their own colors used in the animation. Additionally, each cartoon has a game associated with it. Some games allow you to change the language of the song. Other games allow you to hear different animals or musical instruments. Another allows you to change the sky from day to night.

Not only do these "game" elements fascinate children, but they also encourage creativity, passive language acquisition and hand-eye coordination.

**Figure 6:**
**CD-I Entertainment Title: Children's Animation**

Another PIMA title starts where most computer games stop. "Palm Springs Open" allows you to play on some of the world's most famous golf courses with commentary from professional sports commentators. Like computer golf games, it allows you to pick your club and adjust your power and swing to allow for wind and the lay of the course. It goes one step further in providing professional hints from PGA golfers on playing a hole. It also *reacts* to your play with humorous or complimentary commentary on your golfing prowess. It even shows your ball dropping into the water with a resounding splash when your swing includes too much slice or hook.

Another area of entertainment relatively untouched by other media is vicarious travel. People love to see unique and exotic locales they will probably never visit. Through CD-I self-guided tours, not only might they see the sights of Bombay and the Malabar Caves, but they might hear the wind whistle through the temples and the sounds of the bazaar. Additional cultural and historical information could be provided in a layered manner, so that different interest levels could be accommodated.

For the true traveler, a traveler's tips and itinerary planner could be provided. This might include a language primer and currency exchange section as well as a guide to hotels and hostels. This could be indexed according to cost, interest in cultural settings or linguistic capabilities.

One final example of the use of CD-I in entertainment is an expansion of the current musical compact discs. Most compact discs don't use the full 72 minutes available for audio. Consequently, there is quite a bit of space left over for graphics and text. This could be used for song lyrics, facts about the musicians, lists of other recordings and so on.

**Reference Materials**

One of the biggest problems facing researchers is effectively sifting through the massive amount of information available in libraries. Typically, the only way to find out what's there is through card catalogues or incomplete computer databases.

Just finding the correct book can sometimes be a problem. And even then, when the proper books are found, there is still the tremendous effort needed to wade through them for the desired passages or information.

Another dilemma is the physical size of reference books. To have the books you need at hand requires either a very large (and messy) desk or a large bookcase at arm's length. Unfortunately, this does not allow you to move your research easily.

CD-I has the potential to solve these research problems. CD-I databases for libraries are a natural extension of the current CD-ROM databases.

They would be cheaper in many ways, however, because of their independence from computer systems.

Putting common reference materials on CD-I discs with intelligent searching and indexing systems could circumvent hours of frustration currently found in the research process.

The physical size and weight differences are self-evident. The current Encyclopedia Britannica is 32 volumes and takes up a few book shelves. It could be contained on two CD-I discs that could be put in a coat pocket for travel to and from work.

An encyclopedia title could include sound bits and full-color images to accompany encyclopedia articles. This alone is quite a step beyond the average 30-volume set of encyclopedias.

The possibilities for interactive reference materials are overwhelming. Imagine being read an article on the Siberian tiger while viewing full screen color images of the tiger in its environment and hearing it yawn, roar or play with its family.

One current example CD-I title is the Smithsonian museum disc, again published by PIMA. While this title is intended as entertainment, it uses a fascinating index system that could be adapted for research purposes. This index system allows you to walk through the exhibits geographically, as if you were physically there in Washington, D.C., *or* chronologically by picking out dates and topics *or* topically by exploring your interests. Upon viewing an exhibit, you have the option of continuing with the same type of exhibit or choosing from a list of exhibits that you might like, based on your viewing choices.

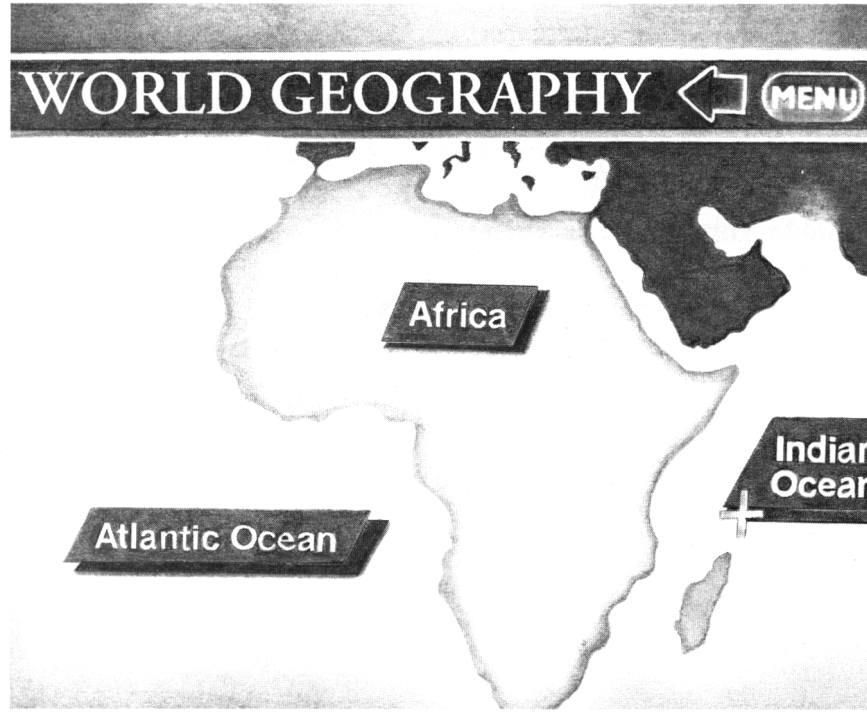



**Figure 7:**
**CD-I Reference Title: Multimedia Encyclopedia**

Such a user-oriented indexing system allows each person to choose a personal method of exploring a title. Each method creates, in effect, a totally different viewing experience. Consequently, the title can be used over and over again without repeating the same sequence or viewing effect.

In the same fashion, a research title using an intelligent index system might provide cross-references by topic, author or even research method. The cross-references are only limited by the publisher's ability to index an article.

One final area of reference titles that could be very useful is the home reference library. These titles could range from medical reference materials to recipe books, from how-to encyclopedias to dictionary/thesaurus/grammar/educational reference books for home study.

## Commerce

There are three distinct uses of CD-I in the sales/marketing area: point-of-information, point-of-sale and marketing presentation.

*Point-of-Information Titles*

This could be one of the first public uses of CD-I. The acceptance of information touch screens in today's department stores proves the public's readiness to use such technology. The use of CD-I could be even more dynamic in large cities by the use of multilingual audio tracks.

The type of information systems used in Disney World could be easily adapted to retail information systems for mall-wide inter-store use. Each store could include monthly specials that could be previewed and/or ordered by touch screen and credit cards from remote locations for later pick-up or delivery.

As mentioned in the last chapter, CD-I could be used as a sales information tool by the salespeople. Our shoe store example could be expanded to almost any national retail outlet: clothing, sporting goods or automobiles.

Imagine selling a car. The potential customer might have found the model he wants. The color might be wrong or the extras package isn't a perfect match. Today, the customer goes home and mulls it over. With a CD-I auto reference title, the salesperson pulls up the appropriate model, color, package and price on a large color screen. The customer can view the interior, the dash, tires, bumper or whatever details he wants. He can read about the technical specifications and, if available, favorable reviews by car magazines.

Again, this does not replace the customer services that a store might provide, but it allows a valuable additional service for customers, especially during peak traffic hours when sales clerks are notoriously hard to find.

Another example of a point-of-information title comes from the music industry. In European music stores, it has been historically common to preview an album before purchase. The customer only had to ask a clerk

to listen to a song, and headphones and a turntable would be provided. This service could be provided by CD-I in the same fashion as the video jukebox. In this case, however, the interface would not be slipping quarters into the machine to choose a song/video to play, but perhaps choosing a musical style (rock, pop, country, classical) and a selection from a centrally-located touch screen. The selections could be changed on a regular basis by a subscription service with monthly additions or substitutions.

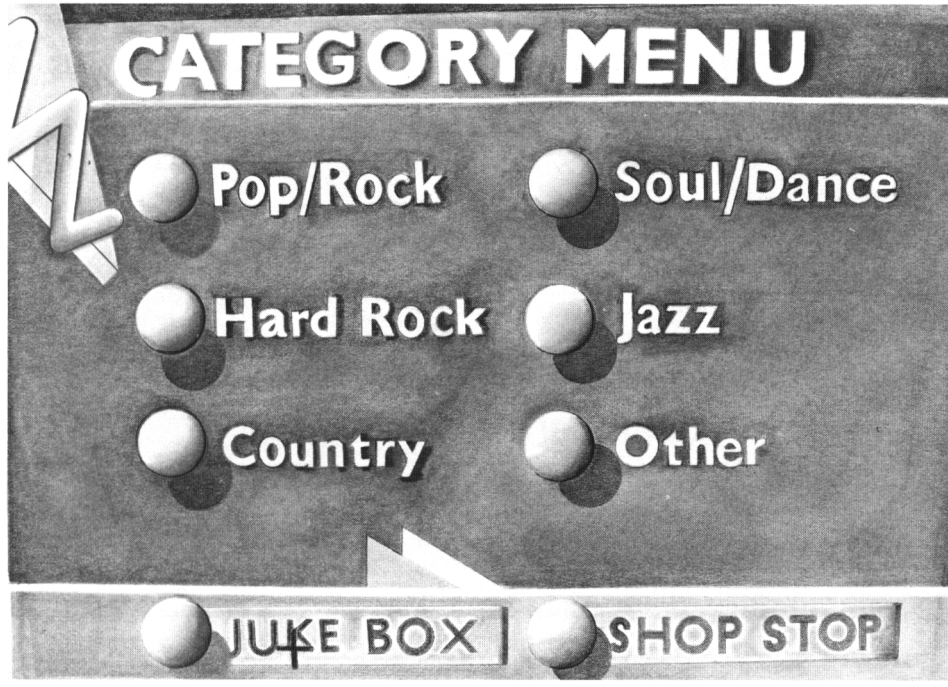



**Figure 8:**
**CD-I Commercial Title: Video Jukebox**

*Point-of-Sale Titles*

Catalogue sales are becoming more and more of a reality for much of the world. They now are a standard service for most national retail stores. No matter where you live, you get mail and consequently can purchase items through the mail.

What is most disconcerting about mail-order, is the lack of immediacy in ordering. In most catalogues, the items to purchase are small pictures with, at best, one or two phrases describing the essential qualities (twill-knit, gray/blue or black/red, S/M/L/XL). It is not unexpected to purchase something and find it not exactly what you had in mind.

**Figure 9:**
**CD-I Commercial Title: Video Mall**

CD-I is not a solution to poor selection; however, it does not suffer from the printed catalogue's problem of trying to put too much information into too little space. A CD-I catalogue could include pictures of the sales items in various colors and sizes on different models. Full material information and cleaning instructions could be provided up front. The entire sales inventory could be included on a single disc.

While these discs could be distributed in the same manner as catalogues, they would provide better service as part of a retail center: a video mall,

if you will. Small towns that can not support a large department store or a specialty boutique could now enjoy the same benefits as large cities (without the lines, ...hmm...).

*Marketing Presentations*

If you have ever created a slide show or overhead presentation, you understand the planning and frustration involved. Typically, a presentation is customized for a specific audience from a standard stock of slides or overheads. The customization may consist of creating new slides, combining more than one previous presentation and making hard copies of all the material.

Imagine having all your slides on a single CD-I disc. The slides are organized in a top-down information hierarchy: the main flow is overview information with detailed slides as a sub-layer.

The order of your slides can be stored in memory ahead of time, in the same fashion that you would choose the order of slides in a carousel. The difference here is that you have access to all the slides instead of merely the ones you brought with you.

As you give your presentation, you are able to provide much more detailed information as your audience asks specific questions. This can be accomplished through *hot* text. A detail slide may be linked to a specific item on the screen. By clicking on the word or graphic, the detail slide appears for specific reference. This type of capability allows the presenter to customize the presentation *before* and *during* the presentation.

Now, add the video, animation and sound capabilities. Actual photos of a product in various environments can be presented. Or, as you discuss a process, you can show your audience an animated sequence illustrating your point.

With the advent of full-motion video, the presentation uses of CD-I will become phenomenal.

All of these CD-I features could be very powerful additions to the current *standard* visual presentation of slides, overheads and videotape. Because of its visual power, CD-I could become the *new* standard in presentation.

# THE STRENGTHS OF CD-I

As we have shown, the uses of CD-I seem limited only by your imagination.

The user's ability to interact with the CD-I title is by far its strongest capability. It allows individuals to control how they view information. This sense of control is very important. It promotes active self-exploration and creativity. Very few media can claim this.

The ability to provide various levels of information is also linked to the interactivity. In one sense, this medium can be seen as educational at all times. By organizing the information in a hierarchical fashion, users can request more detail as they want it and when they want it. This allows single titles to be targeted at many audiences of various educational and interest levels. Again, few media accomplish this.

CD-I is not a sequential medium; this is related to its interactivity. Other visual media tell stories or provide information in a pre-determined sequence. The viewer must follow along the producer's line of reasoning with, at best, the ability to review the sequence if it is unclear. CD-I's multi-level approach allows for sequential information to be presented, and also allows for non-linear digressions to be built in for users to explore at their convenience.

Finally, CD-I does not appear as overwhelming a technology as computers. It has a familiar look. It is a simple plug-in, audio-visual/stereo component. It is an addition to the TV. There are no extensive and incomprehensible assembly or installation instructions: connect it to your TV, insert a disc and you're ready to go.

Because of these strengths, CD-I appears to be the ideal medium for education and reference. It fits into certain areas of commerce and entertainment like no other media. Finally, it opens new areas of communication that do not exist today but will only be possible through a medium such as CD-I.

♦ FOUR ♦

# THE FUTURE OF CD-I

## Extentions

One of the biggest questions asked of CD-I is "What comes next?" Now that we have snuck personal computers into every home, what do we do with them? How do we really unleash their power?

### Personal Computers

The first extension for CD-I players will probably be in the area of greater storage. There is only a small amount of permanent (battery-backed) memory in the player. (Details on Non-Volatile RAM are provided in a later chapter.) As more applications vie for this memory, manufacturers will provide Non-Volatile RAM (NVRAM) cartridges or floppy disk extensions for their players. This will let people keep more information about the way they use their players.

Over the past ten years, we have even seen TV sets that have built-in appointment calendars and calculators. Think what can be done with a CD-I player and a 3.5-inch diskette. Will consumers accept floppy disks? We believe the answer is yes.

Over the past eight years, CDs have become extremely popular. Psychologically, CDs are not that different from diskettes. You take a small, flat object and put it in a slot. You can put them in your coat pocket or stack them on your CD shelf. This would never have been possible with the flexible 5.25-inch or 8-inch floppy disks. They were too prone to damage.

The next step will be keyboards. Educational and other institutions will demand them almost instantly. They will start to filter into people's

homes as parents buy CD-I players as personal computers for their kids. Economically, households with existing CD-I players may find upgrading players to personal computers far less expensive than purchasing a complete new personal computer. Educationally, having access to multimedia encyclopedias and electronic dictionaries will make writing reports for school a breeze. (If only I'd had an electronic spelling checker when I was in high school...)

Of course, with keyboards and word-processing software come printers and modems. These extensions form the basis for most personal computer systems. With these peripheral components in place, the standard sorts of productivity software (spreadsheets, databases, etc.) also will become available on the CD-I player.

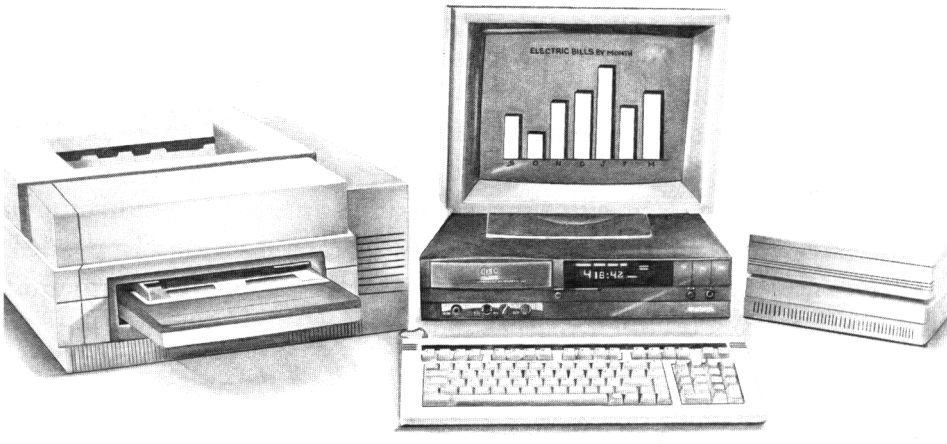



**Figure 10:**
**The Personal CD-I Computer**

## MIDI

One group of consumers who has really latched on to computers over the past ten years is musicians. With the advent of MIDI (Musical Instrument Digital Interface), computers are becoming as commonplace in recording studios as guitars and drums. Virtually every electronic keyboard in the world *talks* MIDI, and now many guitars and drum sets do the same. Both professional musicians and hobbyists will find hundreds of uses for a CD-I player with MIDI jacks.

Hobbyists will use CD-I players for music education and *play-along* titles. Imagine, for example, being asked to play an E-minor scale and having the CD-I player *listen* to you play it. It could print the notes on a staff as you play and then *correct* you if you played a wrong note or pressed one key harder than another. Or it could play a song and listen to you playing a solo melody along with it.

Professionals will use the incredible storage capacity of the CD-I disc for storing high-quality digital *samples* of sounds, as well as using built-in floppy and hard disks for recording music. Because CD-I players are compact, cheap and portable, they make ideal computer systems for musicians. Plus, most importantly, they are universal. If you take a CD or floppy disc to another studio, you don't have to worry about whether they have Macintoshes or IBM PCs, or which version of the operating system they have. All CD-I discs will be playable on all CD-I players anywhere in the world.

**Figure 11:**
**MIDI System**

## Telecommunication Networks

Perhaps the most radical extension to CD-I will be its integration with one of the most common appliances in the world: the telephone. Today, you can pick up a telephone and literally reach out to the whole world. With a telephone and a credit card, you can order clothes, musical equipment, toys, food and magazines without ever leaving your house. They will be delivered to your doorstep within a matter of days.

With 900 numbers, we also have seen an explosion of phone information and entertainment services, everything from news to sports to pornography to religion. Imagine what could happen if your telephone could send video as well as audio. With a CD-I player at the other end, you could literally dial up a movie, any time you want! Or dial up the new Spiegel catalog and place your order without lifting a finger. All you need is a simple phone jack on the back of your CD-I player.

This technology is at hand. It's based on a new phone service called ISDN (Integrated Services Digital Network). ISDN allows you to send audio and video data at just about the same bandwidth as a CD. This will almost certainly revolutionize the way that we use our phones and integrate them with the other electronic appliances in our homes.

**Figure 12:**
**CD-I/ISDN System**

The problem is that you need a different *wire* coming into your house and there are tens of millions of homes in the U.S. that have the *old* wires. But where there is a profit motive, there is a way. And leave it to the phone company to find a way to make money from it....

One potential service for the phone company is in the use of electronic phone books. While producing the Yellow Pages is profitable, there is a problem in that they are virtually out-of-date by the time that they arrive

at your door. By the end of 12 months, the number of inaccurate entries is staggering.

The EYP (Electronic Yellow Pages) project is a way for the various phone companies to provide a much higher level of service to consumers; directory assistance on your TV, updated daily, with *talking ads*. With the addition of on-line transactions, EYP becomes even more valuable.

♦ FIVE ♦

# THE FUTURE OF CD-I

## Will the Public Accept It?

Even with the marketing prowess of Philips, Sony, Matsushita and the other electronics industry giants behind CD-I, there is the question of whether CD-I will be accepted by the public. After all, many very slick products have been released with great fanfare, only to fail after the first year of production. Why is CD-I different?

### Familiarity

One reason is the familiarity of CD-I. It may seem like something new to the industry insider, but to the average consumer, this is just a high-tech compact disc player. It plays music and expands your TV into a graphics display.

The same question of media acceptance was asked of CD-DA music discs when they first were released. The initial reluctance to *switch* to CDs from LPs caused many music industry insiders to predict the failure of CDs. The subsequent rise of CDs to prominence, however, is an established fact. While we cannot assure the world that CD-I will enjoy that same success, we can point to the public's acceptance of a new medium as a good sign. Additionally, CD-I is not replacing a popular medium like the LP. Instead, it is *enhancing* the CD format.

### Cost of Players

The cost of CD-I players will start at under $1000. This is encouraging. Current high-tech stereo components are in the same price bracket. CD-DA players range from $175 to $1000 depending on features,

brands and markets. When CD-DA players were first released, they too had higher price tags. Consumer demand has largely been responsible for bringing the price down to its current levels. There is no reason to assume a different pattern of growth for CD-I. In fact, it is entirely possible that within five years, you will not be able to buy a CD audio-only player. CD-I players may completely replace the market.

## Cost of Titles

The cost of a single title will initially be in the $20 to $50 range. This is again encouraging. This pricing is not out of line with what game players paid for Nintendo cartridges or what VCR movies cost today. Like all media, the price will eventually be decided by the market demand. If CD-I has the public acceptance of CD-DA or VCR videotape, the price will decrease dramatically in the first few years.

## Video Features

The public is in love with video: television, music videos, movies, VCRs. The public has an enormous appetite for video media. CD-I is situated in a way to take advantage of this love affair.

Like the VCR, it is an additional component of the television. Like the VCR, it provides entertainment for a wide variety of tastes. Like the VCR (when merely viewing pre-recorded material), CD-I is simple to operate: insert disc, and press play.

CD-I has the stereophonic capabilities of CD-DA discs. With full-motion video, it will have the capabilities of reproducing full music videos. This could revolutionize the music industry *again.* The longer playing time of the CD-DA discs changed the nature of the *album* so that it is now not uncommon to find 60-minute releases with various versions of the same song on a single disc. In this same fashion, the capabilities of providing music videos on compact discs might become the standard.

## Interactivity

Research being done throughout academic circles points to a growing trend toward the use of interactive media. Currently, the media darling is HyperCard. This again bodes well for CD-I.

HyperCard and other *hyper-media* soften the CD-I market. That is, the way is being paved for public acceptance of interactive media. Through the schools' use of HyperCard via Apple computers, a growing number of students are being exposed to the world of interactive media. This can only help CD-I.

Another market that provides an idea of the public's acceptance of interactivity is in the video game market. Not only are these video players interactive, but they have other striking similarities to CD-I. First, they are computers being marketed as electronic stand-alone units. Second, they require the purchase of fairly pricey cartridges in addition to the cost of the original player. Finally, they plug into the television and use a variety of remote controls, joysticks, etc. to control the interactive game playing.

## Extensions

What may finally cement the relationship of CD-I to the public may be the variety of uses to which CD-I can be put. America loves gadgets, and in that sense, CD-I is the end-all of gadgets. As electronic services become more common, the uses for CD-I become more apparent.

For such services as the electronic yellow pages, a single consumer interface is necessary. In the fashion of the telephone, the service may demand an economic consumer technology. In this instance, the technology has arrived. Hopefully, the services will follow in short order.

## Summary

All these indicators point to a public willing to try new media. They point to a public that wants exciting, dynamic, electronic gadgets. And the public is willing to pay the entry price.

What is not said above is that the real acceptance of CD-I will depend not on the pricing or the capabilities of CD-I but on the actual quality of the titles that are produced. If we as an industry produce titles to catch the public's attention, CD-I will succeed phenomenally. If we do not, CD-I may muddle along slowly.

# A Technical Perspective

♦ SIX ♦

# THE CD-I PLAYER

## Overview

As we have suggested earlier, CD-I could well be the Trojan Horse that fulfills the dream of having a computer system in every home in the United States (not to mention Japan and Europe). It is one of the most powerful home entertainment and information systems ever introduced. Ironically, the reason that people will buy it is that it is NOT a computer.

Many of its features may well lie dormant for several years until CD-I is more entrenched in people's life styles. At that point, it has the potential to evolve into a complete home information system. By mating with telecommunications technology, everything from the Library of Congress to the latest Spiegel Catalog could be available on your TV set.

All of this merits taking a closer look at the CD-I player itself and the features that are hidden in it.

# Technical Overview

Technically, a CD-I player is configured much like a personal computer. It has a CPU, some RAM, a CD controller, an audio controller, a video controller and a pointing device. It uses a TV set for its video and a TV or stereo for audio.

It also has some battery-backed RAM for remembering things even when it is turned off, a clock/calender chip so it knows what date, day and time it is, and an operating system called CD-RTOS (Compact Disc-Real Time Operating System).

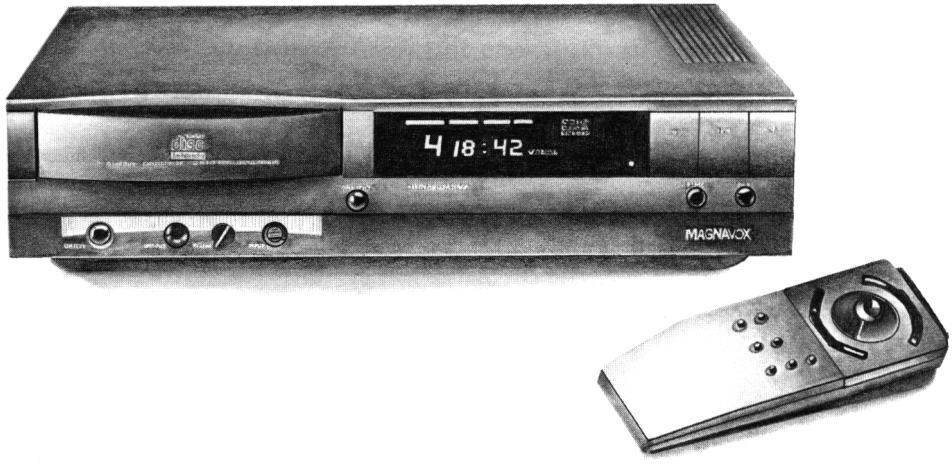



**Figure 13:**
**A Base Case CD-I Player**

Functionally, the CD-I system is divided into six distinct components. The first five components are *hardware*; that is, things you can touch. These components are controlled by micro-processors:

- the CD System
- the Audio System
- the Video System
- Input Devices (mouse or remote control)
- Non-Volatile Random Access Memory (NVRAM)

The sixth component is the operating system, CD-RTOS. It is the software *glue* that holds these components together and creates an integrated, logical *system.*

CD-RTOS, in turn, mirrors the five hardware components of CD-I. For each of the primary hardware components, there is a software module to manage that component; each being more or less independent. Sitting in the middle of these managers is the CD-RTOS Kernel. The Kernel is, more or less, a traffic cop that controls access to the hardware and other resources of the system.

The following chapters will discuss the hardware components individually and then discuss the ways in which CD-RTOS manages them.

♦ SEVEN ♦

# THE CD-I PLAYER

## Hardware

A CD-I disc is quite similar to a phonograph record. There is a continuous spiral of information, starting in the middle of the disc and working to the outside (fingerprints or other listening obstructions are more likely to occur at the outer edges). The difference of course is that phonograph records are played with a needle. CDs or optical discs are "played" with a laser.

The surface of a record contains bumps, which vibrate the needle in a way that reproduces the music. This is considered an *analog* representation of the music. The groove of the optical disc, on the other hand, contains small areas that either reflect or don't reflect the light from the laser. This allows for the storage of information digitally (i.e., strings of 1s and 0s). Because there is no needle to *wear down* the grooves, discs never wear out.

# CD Basics

Optical discs come in many sizes and flavors (Video Discs, CD-Video, CD-Digital Audio, CD-ROM, CD-I, etc.), but of all these technologies only a small group have maintained some form of compatibility with each other:

- CD-DA
- CD-ROM
- CD-I

In the evolution from CD-DA to CD-ROM and CD-I, a decision was made to conform to certain basic principles. Each of these disc types has the same physical size, uses the same laser and spins at the same rate. For the purposes of this chapter, we will collectively refer to these three disc types as CDs.

## Tracks

CDs are logically divided into *tracks*. On music discs, tracks typically correspond to songs. There are a maximum of 99 tracks (or songs) per disc. A *Table of Contents* for these tracks is maintained at the beginning of the disc to allow the player to quickly find the next track.

CD-I allows you to put CD-DA tracks and CD-I tracks on the same disc. This is the idea behind a project called "CD-I Ready." Record companies, with their thousands of music videos, would like to *tease* people into buying CD-I. You may begin to see music discs that have a CD-I track at the beginning of the disc. If you put it into a CD-DA player, it will simply skip that track and go straight to the music. If you put it into a CD-I player, you get music videos.

## Sectors

Although most music discs do not use it all, the maximum playing time of a CD is about 72 minutes. This is the time that it takes the laser to travel from the innermost part of the disc to the outermost part.

The data on the disc is divided into small blocks called *sectors*. These are the smallest units that a CD drive can address. On CD-DA systems, the laser reads the disc and transfers these sectors into the audio processor (AP). The AP processes each sector in exactly the time it takes the laser to read and send the next sector (75 times per second). You hear the processed data as a continuous stream of music.

On CD-I systems, the data can be transferred to the AP or into memory, where the application or CD-RTOS can store it for later.

*Sector Types*

Each of these sectors contains 2352 bytes of information. In CD-DA format, each byte is used for storing music. In CD-ROM and CD-I format, however, the decision was made to use a certain portion of each sector for Error Correction and for describing the type of data in the sector. In music, an error is heard simply as a "pop" or a subtle background noise. While not desirable, it is not disastrous; the music still will play.

In the world of computers, an error could be fatal. If the error is in the application program, it may not run at all. If the error is in a database, it may display an incorrect record or cause other more subtle errors. This is clearly not acceptable.

The Error Detection and Correction Code is an attempt to reduce the likelihood of errors in the critical areas of a Compact Disc. But since it consumes more than ten percent of the sector, it is used only where necessary.

In all, there are four types of sectors found on CDs: Audio, Mode 1, Mode 2 Form 1, and Mode 2 Form 2. Audio-type sectors refer to those used on CD-DA discs. Mode 1 sectors are used on CD-ROM discs, and Mode 2 sectors are used on CD-I discs.

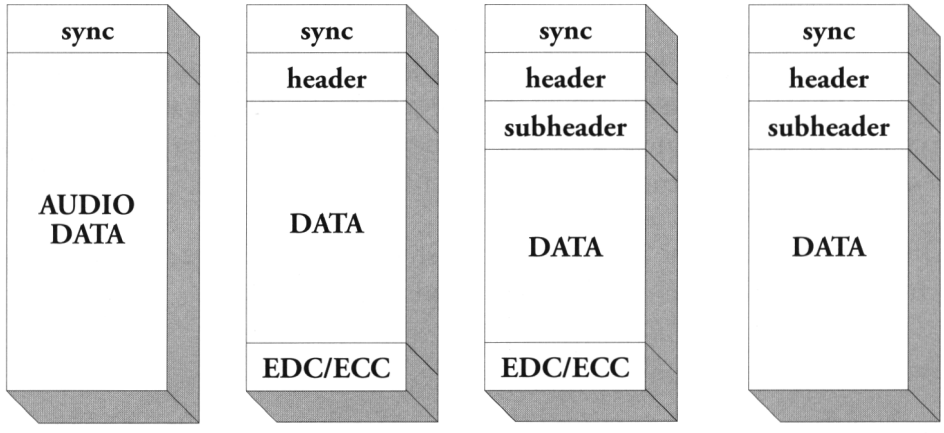



**Figure 14:**
**Audio, Mode 1, Mode 2 Form 1, Mode 2 Form 2 Sectors**

The header of the Mode 1 and Mode 2 sectors contains a copy of the sector address (used in the disc manufacturing process) and a flag indicating Mode 1 or 2.

The subheader of the Mode 2 sector allows the application to more easily separate various data streams when playing the disc. Each sector is labeled Audio, Video, Data or Empty. Additionally, each subheader contains a channel number to further separate the data into its component streams.

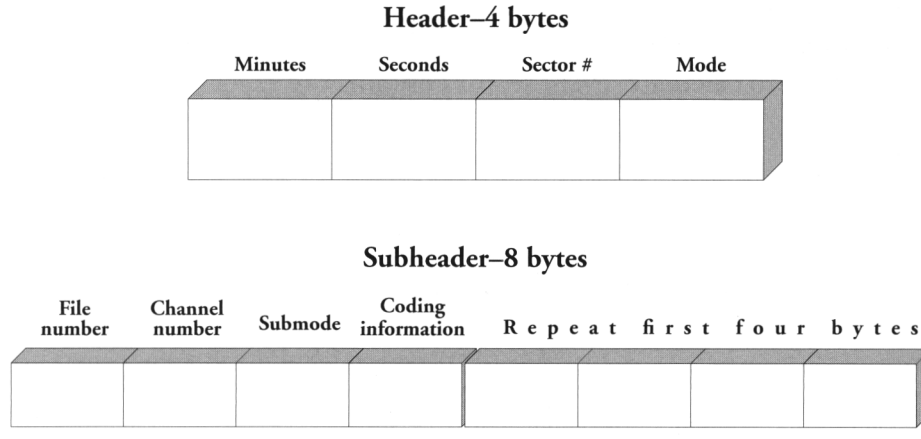



**Figure 15:**
**Picture of Header and Subheaders**

Another useful feature of the submode byte in the subheader is the availability of Trigger and End-of-Record (EOR) bits. Trigger bits are often used to synchronize animation when the application is using variable-sized frames. EOR bits are often used to separate video images within a larger file. These bits act as flags embedded in sectors to synchronize or even further separate the data. Whenever a trigger or EOR bit is detected, the application is sent an appropriate signal to register the event.

Finally, the subheader provides a mechanism for identifying data as *real time*. In this context, real time means *timing is more important than correctness.* If data is not real time, the system will try to correct the errors, even if it slows down the disc access. Errors in real-time data (typically audio or video) will not be corrected, unless the player can do it without slowing down.

## Disc Capacity

When calculating how much space a CD holds, it is important to take into consideration the type of data that is being used on the disc. CD-DA discs are easy to calculate; every sector contains the exact same amount of data:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 72 | * | 60 | * | 75 | * | 2352 | = | 762,048,000 (744Mbytes) |
| min | | sec/min | | sect/min | | bytes/sector | | |

The same is true for CD-ROM discs; there is only one sector size available. This gives the application 2048 bytes per sector or:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 72 | * | 60 | * | 75 | * | 2048 | = | 663,552,000 (648Mbytes) |
| min | | sec/min | | sect/min | | bytes/sector | | |

This gives us a rough idea of how much the disc holds. Unfortunately, CD-I does not have only one sector size. CD-I may use any of the 4 sector types, which makes it impossible to plug in a quick disc capacity formula like those above. But these two numbers give the upper and lower limits of the capacity of a CD-I disc.

## File Structure

A key distinction between CD-DA discs and CD-ROM/CD-I discs is the concept of *files*. The only subdivision for music discs is the track, or song. CD-ROM and CD-I discs may contain hundreds or thousands of files which need to be uniquely identified. Files have names and can be organized into *directories* (sometimes called *folders*).

Both CD-ROM and CD-I are based upon the ISO-9660 format for file structures on a compact disc. This international standard describes a hierarchical file structure just like that supported by hard disks. Adherence to this standard allows CD-I players to access files on either CD-I or CD-ROM discs.

## Disc Label

The first several sectors of a disc contain the *disc label*. The label contains information about the disc, such as the name of the disc, the author, the

publisher and the date of publication. In many ways, this is comparable to the first several pages of a book. Most importantly, though, the label contains the name of the startup application. This is the program on the CD that controls the interactivity of the title. When using CD-ROM, this application is usually provided via a floppy disk.

The disc label is followed by the *Path Table*, comparable to a table of contents in a book. The Path Table contains the location of every directory on the disc. CD-RTOS stores this in memory to optimize the time it takes to find a given file on the disc. For more information about the way CD-RTOS manages the CD system, see the section on CD-RTOS and the Compact Disc File Manager (CDFM).

# AUDIO BASICS

CD Audio has set a new standard for excellence in consumer products over the past ten years. Suddenly, all of those records and cassette tapes that always sounded pretty good are nowhere near good enough.

Technically, CD audio is called PCM or Pulse Code Modulation. The theory, in simplified terms, is to take a snapshot of the music sound wave 44,100 times per second, and store that snapshot as a 16 bit number. This *sample rate* of 44.1 KHz allows the audio processor to very effectively reproduce the essence of the music.

CD-I utilizes PCM audio as well as three new types of audio. These three new types are based on ADPCM or Adaptive Delta Pulse Code Modulation encoding. They use a lower sample rate (37.8 and 18.9 KHz) and a lower bit rate (8 or 4 bit), but they help make up for it by only recording the difference (delta) between one sample and the next. This gives the higher quality ADPCM audio close to the same quality as PCM.

These three new levels are called, respectively, A, B and C. They are available in both monaural and stereo, for a total of six new options.

| Audio Level | Sample Rates | Frequency Range |
|---|---|---|
| PCM (Super Hi-Fi) | 44.1 KHz 16 bits | 20 KHz |
| Level A (Hi-Fi) | 37.8 KHz 8 bits | 17 KHz |
| Level B (Mid-Fi) | 37.8 KHz 4 bits | 17 KHz |
| Level C (Lo-Fi) | 18.9 KHz 4 bits | 8.5 KHz |

**Table 1:**
**Audio Levels and Sample Rates**

The chief reason for using ADPCM audio is that it uses much less space on the disc. PCM audio uses the entire "bandwidth" of the disc (i.e., every sector must be an audio sector). Level A stereo uses only half of that space, leaving more space for graphics and other data or allowing for

more than two hours of recorded music on the disc. Level B uses half the space of level A. And level C uses half the space of level B. In each case, monaural audio uses only half the space of stereo audio at the same level.

| Audio Level | Recording Time |
|---|---|
| Level A – Stereo | 2.4 hours |
| Level A – Mono | 4.8 hours |
| Level B – Stereo | 4.8 hours |
| Level B – Mono | 9.6 hours |
| Level C – Stereo | 9.6 hours |
| Level C – Mono | 19.2 hours |

**Table 2:**
**Recording Time for Each Level**

## Audio from Disc

When audio streams from the disc into the audio processor, it must arrive at exactly the rate that it is needed. There is almost no tolerance or buffering built into the system besides the one-sector increments of the CD itself. This necessitates what is known as audio interleaving. In other words, ADPCM audio sectors have to be spaced out on the disc so that they don't arrive too quickly (or slowly) for the audio processor.

As each sector is transferred from the disc to the audio processor (AP), the AP slowly decodes it and turns it back into music. The next sector arrives just as the last one is finished, allowing for "seamless" audio, even though it arrives in blocks.

As mentioned before, PCM audio takes up the full bandwidth of the disc; every sector must be an audio sector. Since 75 sectors are delivered every second, each sector must contain about 1/75 of a second of audio or about 13 milliseconds.

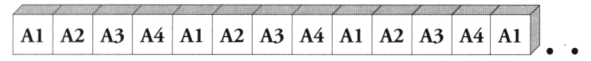
Since Level A stereo can pack twice as much data into a sector, it must be spread out on the disc so that sectors arrive only 37.5 times a second. Effectively, this means that every other sector on the disc is an audio sector. Level A mono and level B stereo use only one out of every four sectors. Level B mono and level C stereo use only one out of every eight sectors. And level C mono uses only one out of every 16 sectors.

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A Stereo | X | | X | | X | | X | | X | | X | | X | | X | |
| A Mono | X | | | | X | | | | X | | | | X | | | |
| B Stereo | X | | | | X | | | | X | | | | X | | | |
| B Mono | X | | | | | | | | X | | | | | | | |
| C Stereo | X | | | | | | | | X | | | | | | | |
| C Mono | X | | | | | | | | | | | | | | | |

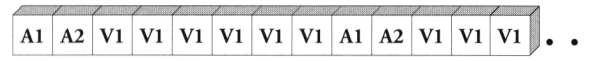
**Table 3:**
**Interleaving Possibilities**

The intervening sectors may contain video, program data, empty space or other audio sectors with different channel numbers in the subheader. This interleaving of audio sectors with different channel numbers is a very useful feature of CD-I and will be described in a subsequent chapter on real-time files.

Applications use this mechanism to implement multilingual soundtracks to a video segment or to extend the audio playing time of an application. Files like this may be played dynamically, switching between the soundtracks, or by listening first to the audio on one channel and then replaying the file, listening to audio on the other channels.




**Four audio channels (B Stereo) interleaved**




**Two audio channels (B Mono) interleaved with video**

**Figure 16:**
**Interleaving Possibilities**

## Audio from Memory

The other possibility with audio is to read it into a buffer first and then to play it back at a later time. Audio stored in memory is called a *soundmap*. Soundmaps are typically used for short sound effects, as the amount of memory required to store audio is quite large.

If you consider that the CD delivers 75 sectors per second at 2304 bytes of ADPCM audio data per sector, and level A stereo audio uses every other sector, to store one second of A stereo audio in memory would take about 84K bytes. Ten seconds of audio at this level would use virtually every byte of memory in the system!

Even level C mono takes more than 10K per second, which makes five to ten seconds a practical limit for most applications. This limit, however, is more than enough for typical applications that want to store a few beeps and whistles, or simple "Yes," "No," "Correct" or "Try Again" prompts.

Audio may be played from disc or from memory, but not at the same time. It is possible, however, to read audio into memory, mix it with audio already in memory and then play it out. More information on audio mixing is provided in the later section on CD-RTOS and audio.

| Audio Level | Space for 1 second of audio |
|---|---|
| A Stereo | 84 Kbytes |
| A Mono | 42 Kbytes |
| B Mono | 21 Kbytes |
| C Mono | 10.5 Kbytes |

**Table 4:**
**Soundmap Memory Use**

# Video Basics

No one is really surprised that CD-I delivers great audio. After all, it's built upon the CD-DA standard of excellence. People have been relatively surprised, though, at the quality of video delivered by the system. CD-I looks more like what you would see on TV than on a PC or Macintosh. This is due to a fairly complex set of video processors.

Specifically, there are three video components in a base case CD-I player: two Video System Controllers (VSCs) and one Video Synthesizer (VSR). Technically speaking, these three components do not have to be physically separate chips, although *first-generation* players will implement them as such. Fully integrated VLSI implementations are planned, but even then, title designers can treat the VSCs and VSR as being logically separate.

The VSCs are each responsible for displaying an image. The VSR (or video mixer) is responsible for combining the two images, often referred to as video planes, into the final image you see on your TV or monitor. This is useful for creating *dissolves* or *wipes* from one image to another, or for creating *windows* through one image to the next.

## Video Resolution

The picture on your television set is actually made up of thousands of individual dots. These colored dots are typically referred to as *pixels*. The quality of the image on your TV is partially determined by how many pixels are displayed on each line and how many lines there are. Throughout the world, there are only two basic standards for TV sets: PAL and NTSC. PAL is used throughout Europe and South America, NTSC is used in North America and Japan.

NTSC specifies 384 pixels on each line with 240 lines. PAL defines 384 pixels per line, with 280 lines. Just to make things confusing, there is also an NTSC *monitor* mode which displays images at 360 pixels per line with 240 lines.

| Resolution | Width | Lines |
|---|---|---|
| NTSC Monitor | 360 | 240 |
| NTSC TV | 384 | 240 |
| PAL | 384 | 280 |

**Table 5:**
**Video Resolution**

When designing CD-I titles, a developer must choose one of these formats and then master the video accordingly. There are implicit trade-offs for each. If you master a title for PAL (384x280), parts of the image will be cut off when displayed on an NTSC system. If you master for NTSC, then use the disc on a PAL system, there may be blank areas (usually black) at the top and bottom (or sides) of the display. Evaluating these trade-offs is an important part of the design process. Some designers consider the black border unacceptable. Others consider the loss of parts of the image unacceptable.

## Video Data Types

The VSCs are capable of displaying four basic types of images: DYUV, RGB, CLUT and Run Length. DYUV (Delta YUV) is intended primarily for natural images and was created especially for CD-I. RGB and CLUT (Color Look Up Table) are intended primarily for graphic images and text. Run Length is a special compressed version of CLUT used primarily for animation.

### *DYUV*

The DYUV encoding scheme takes advantage of the fact that the human eye is much more sensitive to differences in brightness (luminance) than color (chrominance). It essentially throws away some of the color information and focuses on the brightness information. Although this sounds negative, it is possible to display millions of colors in the same image using this method and it produces very life-like images.

The drawback of DYUV is the D part. That is, each pixel is encoded relative to the previous pixel. (You record the difference between a given pixel and the previous pixel, not the absolute value.) Thus, if you change the value of a single pixel on the display, you will affect every pixel on the line after that point. This renders DYUV unusable for images that will be drawn upon or modified at run time. As it works out though, DYUV will deliver the best quality for most images, and probably will be the most popular format overall.

*RGB*

RGB is a more traditional format that measures the absolute value of the red, green and blue components of each pixel in an image. This value is stored in 16 bits, giving 5 bits per component (R, G and B) with one bit left over to signal a transparent pixel. The actual range of values for R, G and B is from 0 to 255, which would normally take 8 bits to encode. Thus, the 5-bit values (0-31) are scaled to this range when displayed. This gives 32,768 possible colors in an image.

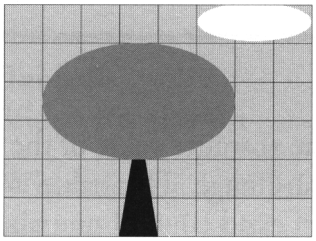
There are two drawbacks to RGB. One is that it takes twice the space to store an image as it does for DYUV or CLUT. RGB images are stored with 16 bits per pixel instead of only 8 for DYUV and CLUT. Thus, a full screen RGB image requires 180-200 Kbytes to display. The second disadvantage is that it takes both VSCs to display an RGB image. You cannot set up overlays with text or other graphics. Overall, this image format will be used least of all.

*CLUT*

The CLUT image format also comes from the traditional world of computer graphics, and there are many variations on this format. Instead of storing the RGB values directly in the image, CLUT picks out the most common colors and places them in a *palette* or *Look-Up Table.* The image then stores only the index of the given color into the table.

By limiting the size of the Look Up Table, it is possible to compress the image still further, to allow for greater resolution. CD-I CLUTs come in three flavors: CLUT8, CLUT7 and CLUT4. The numbers 8, 7 and 4

refer to the number of bits used to reference the lookup table. With 8 bits, there are 256 possible entries (or colors). Seven bits allows up to 128 and 4 bits can refer to only 16 colors. These colors may be chosen out of the 32,768 possible RGB values, but only a limited number may be on the screen at a time. This limitation is the primary drawback of CLUT images.



**Original "Photograph"**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| B | B | B | B | B | D | F | D |
| B | 9 | 8 | 8 | 8 | 9 | B | B |
| B | 8 | 8 | 8 | 8 | 8 | B | B |
| B | 9 | 8 | 8 | 8 | 9 | B | B |
| B | B | B | 6 | B | B | B | B |
| B | B | B | 3 | B | B | B | B |

**"Digitized" RGB Image 24 bits/pixel**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2 | 2 | 2 | 2 | 2 | 3 | 6 | 3 |
| 2 | 5 | 1 | 1 | 1 | 5 | 2 | 2 |
| 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 |
| 2 | 5 | 1 | 1 | 1 | 5 | 2 | 2 |
| 2 | 2 | 2 | 4 | 2 | 2 | 2 | 2 |
| 2 | 2 | 2 | 0 | 2 | 2 | 2 | 2 |

**CLUT Encoded Image 8 bits/pixel**

**Contents**

| CLUT # | |
|---|---|
| 0 | 3 |
| 1 | 8 |
| 2 | B |
| 3 | D |
| 4 | 6 |
| 5 | 9 |
| 6 | F |

**24 Bit RBG Values**

**Figure 17:**
**CLUTS**

The first advantage of using CLUTs is the image size. It is comparable to DYUV, but allows applications to draw on the image after it is displayed. Second, it can be used for text or image overlays on top of other CLUT or DYUV images. Third, the CLUT4 format allows a higher resolution, that is, twice as many pixels per line (768x240 or 768x280) as any other

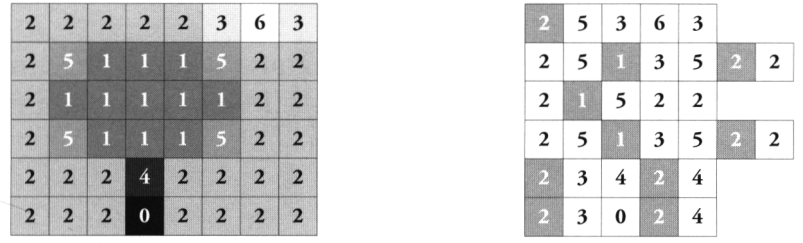
format. Consequently, this format makes high resolution text possible with 80 or 90 column displays.

*Run Length*

Finally, there is an extra twist to the CLUT format. Graphic images, especially animation, quite often use large blocks of the same color. These blocks, or *runs*, can be expressed very compactly using a simple *Run Length compression*. This technique often will allow 100K images to be further reduced to 5 or 10K. At this point, animation becomes possible.

The average Saturday morning cartoon is animated at about 8 to 12 frames per second. At 10K per image, this is only 80 to 120 K bytes per second, well within the range of CD-I, even with an audio soundtrack.

Run Length also is useful for encoding images of text, since there are usually only two or three colors involved in the image.




**CLUT Encoded Image (48 bytes)**

**Run Length Encoded Image (34 bytes)**

**Figure 18:**
**Run-Length Encoding**

## Video Mixing and Special Effects

As mentioned above, the VSR is, more or less, a video mixer. It takes two independent images and combines them into one. It has three basic ways of doing this:

- adjusting the Image Contribution Factor (ICF)
- setting a Color Key for transparencies
- setting a Matte Region

*Image Contribution Factor (ICF)*

Referring back to the audio analogy, the ICF can be thought of as a volume control. Each image's *volume* can be adjusted from minimum (0) to maximum (63). In a typical effect called a *dissolve*, an application would lower the contribution of one image while raising the contribution of the second image. This is one of the most common effects used in video and television today.

Raising the ICF of an image from 0 to maximum without affecting the other plane is called a *fade-in*. Lowering the ICF from maximum to 0 is called a *fade-out*.

*Color Key*

The Color (or Chroma) Key mechanism involves defining a color (or range of colors) that are considered *transparent* in a given image. If a portion of an image is transparent, you would see the second image in that area. One of the classic examples of this is a text or graphic overlay on an image. In this situation, you can create an overlay, move it, or take it away without disturbing the image underneath. This often is used to scroll text or credits over a background image.

Another application of the overlay is in cartoon animation. Very often, cartoons have a stable background image with animated figures moving in the foreground. Instead of encoding the entire image for every frame, you would create the background with no figures, then create the figure animation on a solid background. When you *play* the animation, you de-

clare the solid figure background transparent, allowing the nice background image to be seen underneath.

This is a very effective use of Run Length encoding, since the solid background encoded with the animation takes up almost no space at all.

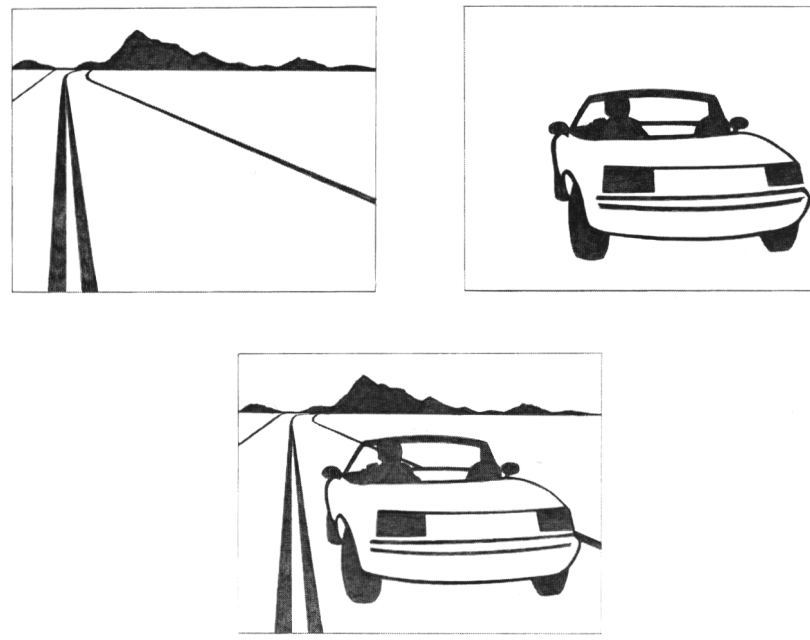


**Figure 19:**
**Color Key Mechanism**

*Mattes*

The matte mechanism defines a transparent area based on absolute coordinates rather than the color content of the image. The matte facilities in CD-I allow the application to specify several mattes on the display at the same time. In addition, they can be specified as fully transparent (ICF 0) or only partially transparent (ICF > 0).

One way to think of a matte is as a picture frame. You can put any picture behind the frame because it has a hole in the middle. Only the frame remains the same.

Now take this a step further. In the larger scheme of things, stationary mattes are rather boring. Imagine instead a matte that grows or shrinks. This is where things get interesting.

Using dynamic matte effects, you can achieve *wipes* (left-to-right, top-to-bottom, etc.), *venetian blinds*, *checker board* effects and many other forms of expanding or contracting shapes.

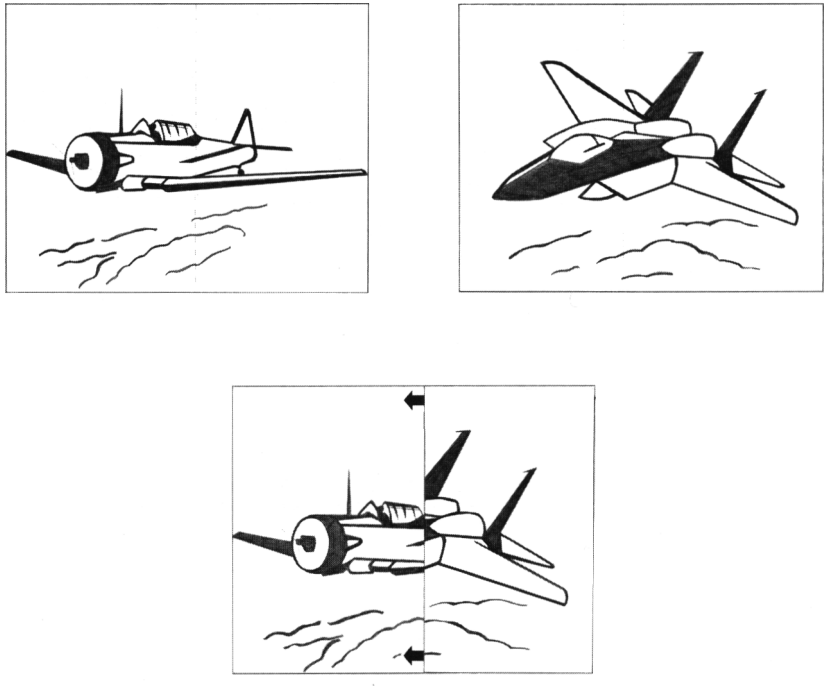


**Figure 20:**
**Mattes: A Right-to-Left Wipe**

# The Graphic Cursor

One interesting component of the video system is the *graphic cursor.* By now, everyone who has used a computer knows what a mouse or a joystick is and knows how it manipulates a cursor on the screen. But most people still have never used a computer.

The manipulation of the graphic cursor is the essence of the nteractivity in CD-I.

The graphic cursor is used to *point* at things in an image. It can be moved either by a person using a mouse or joystick, or it can be moved directly by the application itself.

The graphic cursor can be used to point at anything in the display. In a CD-I Encyclopedia, for example, in an article on human physiology, the cursor could point at organs in the human body, prompting a narration to describe them. On the other hand, the same application might ask the user to point at an organ as a comprehension test in the encyclopedia.

The cursor itself is limited to 16x16 pixels, but it may assume any shape within that size.

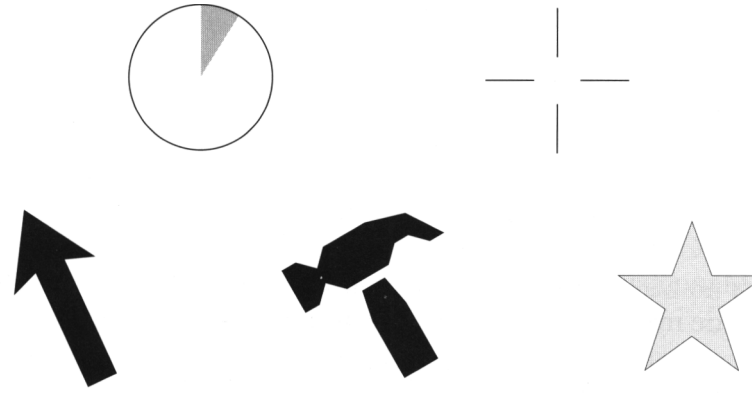


**Figure 21:**
**Sample Cursors**

The cursor may be any of fifteen different colors and may be static or blinking. If the application chooses, the cursor can even disappear completely.

## Pointers

The user manipulates the graphic cursor by means of a pointing device. CD-I describes pointers in terms of four different styles: absolute screen, absolute coordinate, relative coordinate and relative maneuvering.

- Absolute Screen: touch screen, light pen
- Absolute Coordinate: graphic tablet
- Relative Coordinate: mouse, trackball
- Relative Maneuvering: joystick

Absolute Screen pointers are those that require the user to physically touch the screen to control the cursor. These include the touch screens commonly used in lottery machines and point-of-information systems.

Absolute Coordinate pointers are those that require the user to touch something besides the display but still deliver absolute coordinates based on where you touch it. The best example of this is a graphic tablet.

Relative Coordinate pointers include devices such as a mouse. A mouse typically provides information such as "up 2 right 4" or "down 2 left 1." It is up to CD-RTOS to remember where the pointer used to be and to turn this relative information into absolute coordinates.

Relative Maneuvering pointers include devices such as a joystick. Joysticks provide information such as a vector and speed. Typically, joysticks can detect one of eight or sixteen directions (or vectors) and one of three or four speeds. The harder you push it in a given direction, the *faster* the speed. Again, it is up to CD-RTOS to convert this into a meaningful position on the display for the application to use.

Each of these devices will be used within specific contexts for different uses of CD-I. As mentioned before, point-of-sale and point-of-information systems almost exclusively will use touch screens. In these cases, you do not need extremely accurate point detection, and users are in most cases within a foot or two of the display.

Schools and businesses likely will use mice and graphics tablets. They give a much greater degree of control and pinpoint accuracy. In addition, the necessity of having a cable connecting the mouse to the player is not seen as an imposition when seated at a desk.

Consumers in their home will almost exclusively use the joystick or trackball device. Most of these people will actually be sitting on a couch or in an easy chair, holding the pointer on their lap or in their hands. These people will likely use an infrared device like the standard TV/VCR remotes. Cables will not be acceptable for most applications in the home.

## Pointer Buttons

No matter which type of pointer you have available to you, there will be two *select* buttons on it. For a mouse or joystick, this is a standard item. For consumer remotes, there will be more variation and options for presentation of the buttons.

If you think of your VCR remote, it probably has a numeric keypad, several buttons for controlling the VCR (*stop*, *play*, etc.), a *program* button for setting the clock, and a few miscellaneous buttons that *"you never need to touch."*

A CD-I remote will have at least two more. These buttons are special, though, in that they are the key to interactivity with the CD-I title. They most likely will be located near the track ball or thumb pad on the remote and be larger than any other buttons.

Some applications may use the *fast forward*, *reverse* or *play* buttons to mean specific things and emulate them in the context of the application. A movie or encyclopedia article may skip through portions of a narration if the user presses *fast forward*. If the title does not pay attention to that button, pressing it will have no effect.

# NON-VOLATILE RAM

The CD-I Base Case player contains 8K bytes of Non-Volatile RAM (NVRAM). This is RAM that has a small lithium battery connected to it. The result is like having a micro-floppy disk. You can store some information in the NVRAM and it still will be there the next day or the next year, even if you unplug your player and take it to your neighbor's house. It never has to *forget* what you just did. While 8K is not a lot of space in the larger scheme of things, it does allow the player to be *smart* in a couple of important ways.

One classic example is keeping the high score in a game. Your CD-I player could remember, for example, the top 100 scores ever played on your favorite game.

Another example is recording user preferences. For example, if you live in Europe, it is likely that you will buy discs that contain applications in several languages. Without NVRAM, the title would have to ask which language you prefer every time you play the disc. Keeping these types of preferences in the NVRAM makes the CD-I system much more friendly for consumer audiences.

The NVRAM area is managed a lot like a floppy disk. Because it has such a small amount of space, a special file system was developed that has very low overhead and always uses the available space most efficiently. For this reason, directories (or folders) are not available in NVRAM, and the file structure is considered *flat.*

For more information on NVRAM files, see the section on CD-RTOS and NVRAM.

## Full-Motion Video

The most visible shortcoming of the CD-I system is the lack of full screen full-motion video. The importance of this feature cannot be underestimated, especially in the consumer market. However, other market pressures are essentially creating the climate where CD-I will be introduced without this technology in the first generation of players.

As mentioned previously in this book, there are many technologies today that deliver Full-Motion Video (FMV) from optical discs. There are even technologies that can deliver FMV from CD-ROM compatible CDs. Why then doesn't CD-I incorporate this technology?

There are primarily two reasons. The technology used for FMV on CD-ROM discs (DVI) is still extremely expensive and not suitable at all for consumer products. Secondly, consumer electronics demand excellence. CD-DA has delivered on the promise of having the highest quality audio reproduction. The quality of the video could not be less. DVI does not meet that level of quality and there is not yet an international standard for FMV that does.

The closest thing to a standard is called MPEG (Motion Picture Experts Group). The MPEG committee is made up of representatives from the telecommunications industry, the consumer electronics industry and the electronic publishing industry. They have been working since early in 1990 to define a standard that is suitable for delivery from optical discs as well as next-generation telephone equipment.

This level of standardization is extremely important for CD-I, which hopes to field hundreds of millions of units over the next ten to twenty years. Unfortunately, the MPEG standard won't be done before the CD-I system is introduced to the world. This puts CD-I in a tough position of planning for extensions that would be easy in the computer world but are nearly impossible to explain to consumer audiences.

This may lead to a second generation of CD-I+ players or perhaps an upgrade contained on a plug-in cartridge or in an expansion box. Within two to three years, all players will come fully integrated with FMV and

within five to ten years, people will forget that CD-I was launched without it.

## How does FMV work?

Without getting into the murky details of Discreet Cosine Transforms, CD-I Full-Motion Video does compression at two levels. First, there is intra-frame (within-the-frame) compression. Each frame of the sequence is independently grabbed and converted to a YUV format. These images are broken down into smaller blocks or regions for subsequent analysis.

Secondly, there is inter-frame compression and encoding. At this level, frames are examined in sequence to see what the similarities are from one frame to the next. This inter-frame encoding is where the most significant gains are made. At this level, the patterns in the image are examined to see which ones stay the same from one frame to the next. If they aren't exactly the same, they are examined to see if they are just offset spatially from each other. This *motion vector* can be recorded instead of re-recording all of the data in the block for more compression.

Finally, all of this data is filtered one final time, compressed into sectors and put onto the disc. When it is played back, the FMV processor essentially does each of these steps in reverse, decoding the data back at 24, 25 or 30 frames per second.

## Features of FMV

When implemented, Full-Motion Video will be available to CD-I applications as a third plane of video data. The normal CLUT, DYUV and RGB video still will be available and will be usable as overlays on top of the FMV image. The same rules of transparency apply. (Where both planes A and B are transparent, the FMV plane will be seen.)

Also like the normal video planes, it will be possible to encode a *movie* that is wider or taller than the physical display and to show only a portion of the movie.

While the reasons for this may not seem obvious at first, think of a flight simulator example. You could take a movie with a fairly wide-angle lens. As you *steer* the plane one way or the other, you can simply *reveal* a portion of the movie that was not previously being seen. In this way, you can create the illusion of real-time control of a visual sequence without having to stop the disc and look for a different visual sequence.

In the same vein, you can record a sequence that takes up less than the full screen, but then show the sequence in any quadrant of the screen, or even move it while it is playing. This is all controlled by the application as it is running.

♦ EIGHT ♦

# THE CD-I PLAYER

## CD-RTOS

CD-RTOS is a product of Microware Systems Corporation of Des Moines, Iowa. It is a specially configured version of an operating system called OS-9. OS-9 was developed originally for the Motorola 6809 CPU, and was ported to the 680X0 family beginning in 1984. Since then, it has been used extensively in the embedded systems and industrial control market. It has been widely accepted in Japan and Europe as well as the United States.

OS-9 is a multi-tasking, multi-user, real-time, ROMable operating system. These were essentially the features that caused Philips and Sony to choose OS-9 as their standard for CD-I. MS-DOS, while a standard for business computers, was not real time or multi-tasking. UNIX, while a standard for engineering systems, was not real time and was too large to run in a base case player.

The challenge of CD-RTOS was to incorporate the new CD technology and an extremely advanced video system into OS-9.

NOTE:

This chapter is not for casual readers. The terminology used throughout requires a basic technical understanding of operating systems. Do not despair, however; a glossary is provided as an appendix.

# I/O System Overview

One of the distinctive features of OS-9 is its modular I/O system. There is a real-time kernel, which handles process scheduling and resource allocation, and a number of file Managers, each of which handles a class of I/O devices. RBF (Random Block File Manager) handles floppy and hard disks, SCF (Sequential Character File manager) handles serial devices such as modems or printers, and SBF (Sequential Block File Manager) handles tape-oriented devices.

Each of these file managers, in turn, makes requests to one or more drivers that actually communicate with the hardware. By isolating the hardware dependence to the drivers, the system as a whole becomes more easily customizable. New file managers and drivers can be loaded and devices accessed even while the system is running.

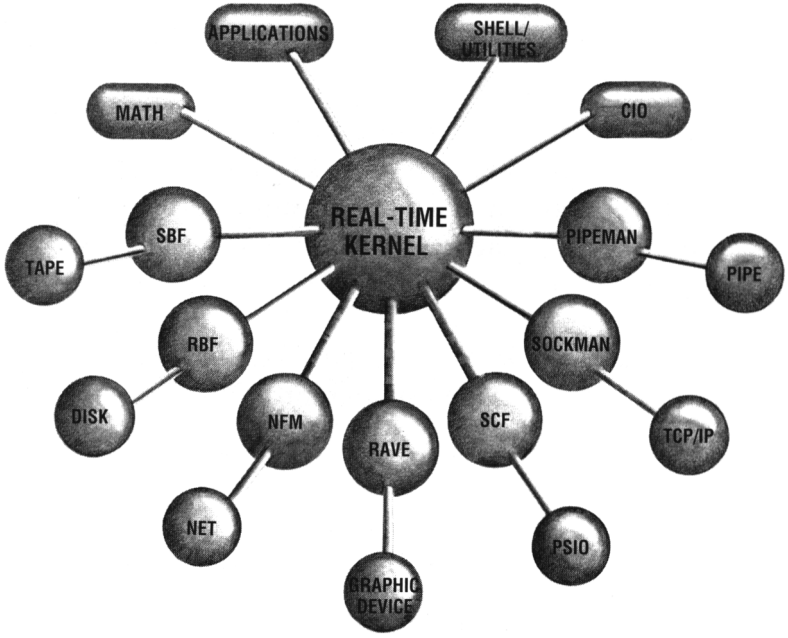



**Figure 22:**
**The OS-9 Real-Time Operating System**

For CD-RTOS, three new file managers were created: CDFM (Compact Disc File Manager), UCM (User Communication Manager) and NRF (Non-Volatile RAM File Manager). CDFM handles the CD and audio devices. UCM handles the video, pointer and keyboard devices. NRF supports the simple file structure in the NVRAM area.

With the addition of Pipeman (Pipe File Manager), which handles inter-process communication, these file managers define the base case CD-I player.

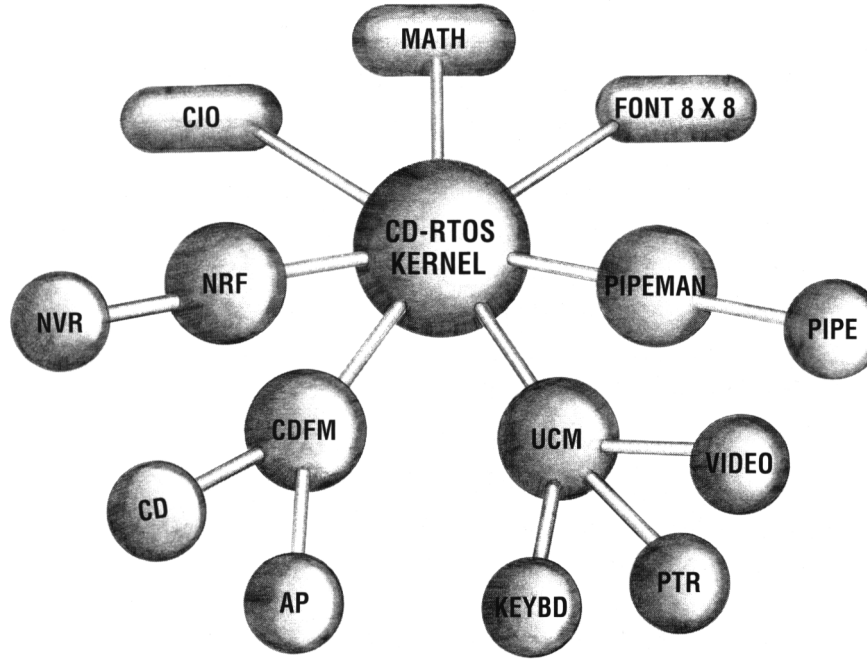



**Figure 23:**
**The CD-RTOS Operating System**

The remainder of this chapter will discuss the kernel and file managers of CD-RTOS.

# The Central Processing Unit (CPU)

CD-RTOS is configured to run on a Motorola 68000 series CPU. This family of processors includes many variations: 68010, 68020, 68030, 68040, 68070, 68332, 68340 and others. A manufacturer may use any one of these processors in its CD-I player. Professional systems may take advantage of the higher processor speeds available with the more expensive processors. Consumer systems will take advantage of the economics available with some of the slower processors.

Since some of these processors are considerably faster than the others, the Green Book had to define the worst-case system performance. This is a 15MHz 68070, roughly equivalent to an 8 MHz 68000. As faster processors become cheaper, a new *de facto* base case certainly will follow.

The significance of defining a processor is that you can consequently write a single computer program that will run on every CD-I player. If some players used Motorola processors and others used Intel processors, for example, this would not be possible.

### RAM (Random Access Memory)

In addition to specifying the CPU, the Green Book requires that a CD-I player contain 1 megabyte of RAM split into two blocks of 512K. The split is necessary due to the architecture of the video system. These blocks are typically referred to as Banks A and B.

While this may not seem like a lot compared with typical computer systems, it's fairly substantial compared to your average VCR or CD player. Like many aspects of the standard, it was chosen as a balance between economics and performance. CD-I players need to be affordable to consumers, not just to businesses and professionals.

As RAM prices decrease over the years, it is likely that manufacturers will begin to include more RAM in their products. Likewise, professional or extended systems may come equipped from the start with 2 or even 4 megabytes of RAM.

As with the CPU performance, it is likely that a new de facto base case will develop over the next several years that will define a much more robust product with additional RAM.

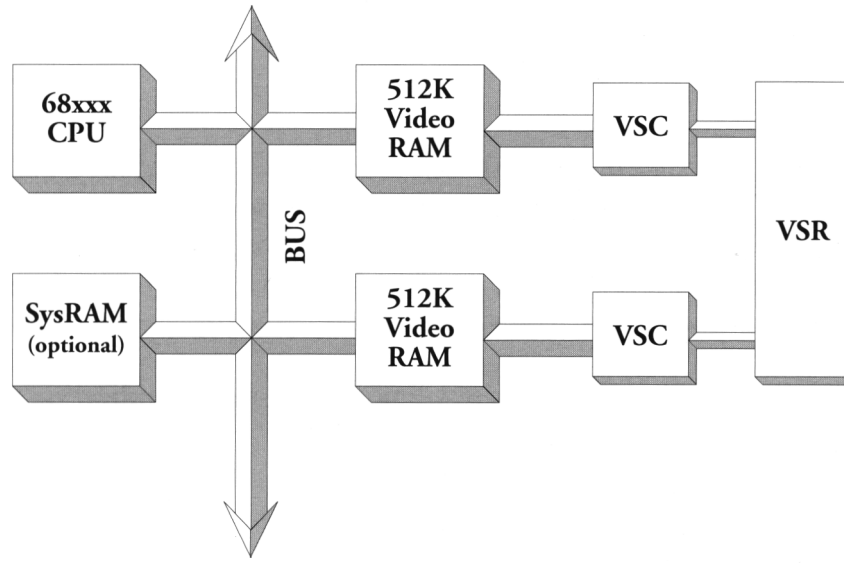



**Figure 24:**
**Diagram of CPU with Memory/Video Section**

# CD-RTOS AND THE CD

The Compact Disc File Manager (CDFM) is responsible for managing the Compact Disc system in a CD-I player. There are three basic software methods for accessing a disc: Read, Play and a special CDDA Play.

## Read

*Read* works on a CD in about the same manner as is used on a hard or floppy disk. You can *seek* to any position on the disc and read any number of bytes. The only restriction is that Read only works on Mode 1 and Mode 2 Form 1 files. These files are typically used for text or databases of information.

Read is a *synchronous* call; that is, it will not return to the application until the disc is actually read.

## Play

*Play* is a special function that was created for Mode 2 Form 2 files, or Real-Time Files (RTFs). Instead of simply reading a file into a buffer, RTF Play separates the Audio, Video and Program data and deals with each independently. Audio data can be sent directly to the audio processor or stored in soundmaps. Video can be sent directly to video image buffers. Other types of data can be stored in generic application buffers for storage and further processing, conveniently sorted according to data type and channel number.

The other unique aspect of Play is that it is an *asynchronous* request. This means that when the application asks CDFM to Play a file, CDFM starts the Play and then returns immediately to the application. The CD Driver notifies the application of the status of the Play by sending it signals or setting *status* variables in the Play Control Block.

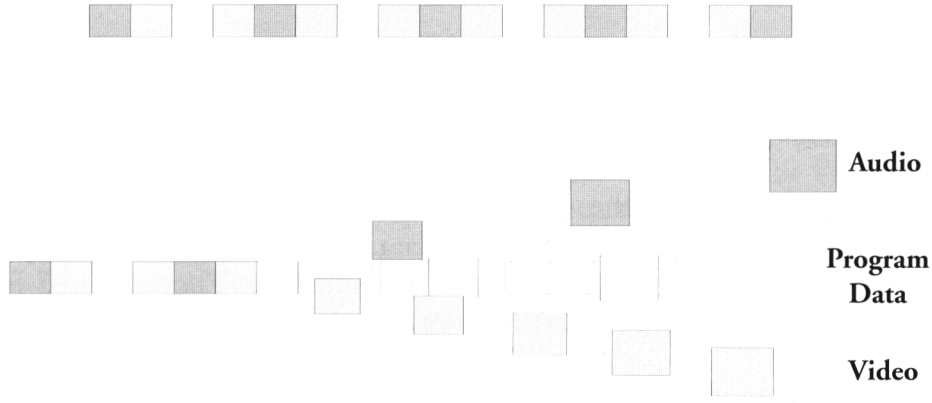



**Figure 25:**
**Real-Time File Data Separation**

## CDDA Play

Finally, there is a special form of the Play call for playing CDDA type audio. Since you cannot interleave CDDA data with other audio or video, it is a much simpler operation. In addition, CDDA audio can only be sent directly to the audio processor. It cannot be buffered by the application. Like an RTF Play, it is asynchronous, so the application would still be able to display video, execute special effects or do other data processing while the audio is playing.

# CD-RTOS AND AUDIO

The Compact Disc File Manager (CDFM) is responsible for managing the Audio system in a CD-I player as well. CD-RTOS gives the application a great deal of control over the audio in the system.

CDFM manages audio through the use of *soundmaps*. Soundmaps are essentially buffers of ADPCM audio data. Soundmaps can be played straight through or looped to repeat over and over. They are used for speech as well as sound effects. They can be stereo or mono.

As a soundmap is being played, applications can further control the volume and stereo placement of the audio. Each channel has separate volume and pan controls. Using these controls, it is possible to ping pong mono signals between the right and left outputs or to cross-fade two mono signals (one right, one left) so that both are heard in both speakers.

Finally, CD-RTOS contains functions for mixing two soundmaps into a third *combined* soundmap. This is not true mixing, as the actual ADPCM samples are not combined, but it will take two mono soundmaps and create one stereo soundmap. Alternately, the right or left channels of two stereo soundmaps can be combined into a new stereo soundmap.

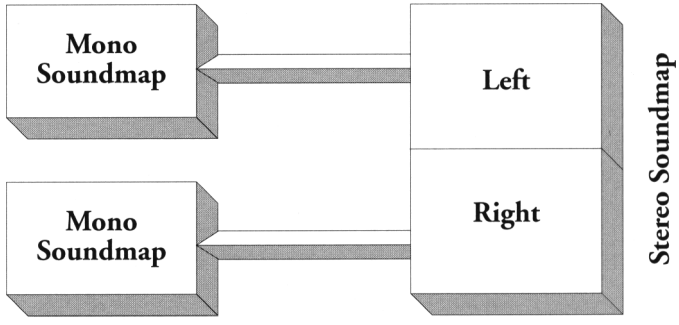



**Figure 26:**
**Audio Mixing**

# CD-RTOS AND VIDEO

The User Communication Manager (UCM) is responsible for managing the Video system in a CD-I player. UCM manages video data through the use of *drawmaps*. Drawmaps contain images to be displayed by the video processors. Drawmaps are typically filled by a Read or Play command and then displayed by the application at the appropriate time.

UCM, however, does more than simply support the display of static images. There are nearly 75 functions for modifying the contents of drawmaps. They include:

- Copying functions to copy or exchange areas from one drawmap to another.
- Drawing functions for drawing any standard shape including: dots, lines, rectangles, circles, ellipses, circular and elliptical arcs and wedges, and polygons.
- Extensive control over pen size, color, pattern, filling, clipping, etc.
- Text functions using either mono-spaced or proportionally spaced fonts.

Text can be placed anywhere on the display and can be anti-aliased using up to 256 colors. Using CLUT7, CLUT8 or RGB modes, UCM supports 40 columns of text with up to 26 lines. In CLUT4 (16 colors), a full 80 column display is possible, with the same 26 lines.

To support word-processing applications, UCM includes CRT-emulation functions with all the common commands such as cursor left, right, up, down, home, insert line, delete line, delete to end of line, auto word wrap, reverse video, etc.

For a complete list of all video functions, refer to the Appendix on the CD-RTOS software interface.

## Video Mixing

The second aspect of CD-RTOS video is managing the video special effects. CD-RTOS helps applications create and execute Display Control Programs (DCPs) to control the video processors. DCPs are actually simple little programs that tell the video processors which colors to use, what image to use, whether to have transparent areas, etc.

This DCP is divided into two parts. Think for a moment about the way a TV works. An electron beam races across the screen, line by line, changing colors as it goes, to create an image. This happens 60 times a second (50 if you live in Europe). As it works out, this beam is *soooo* fast that it actually has some spare time at the end of each line and some more at the end of the screen before it needs to start again. During these times, it is possible to give the processors new instructions.

The first part of the DCP is run just before the first line of video is displayed. This part can be fairly long, up to 1024 instructions. Since there are only 300 instructions the processor even knows, this should be ample. This part of the DCP is called the Field Control Table (FCT).

The second part of the DCP is run just before each line is displayed. This part must be very short. There is only time to execute eight instructions before the display must again be active. Fortunately, this is almost always enough. This part of the DCP is called the Line Control Table (LCT).

The DCPs allow an application to split the screen horizontally between several images. Additionally, they contain the matte or video mixing instructions (described in the previous chapter on video hardware).

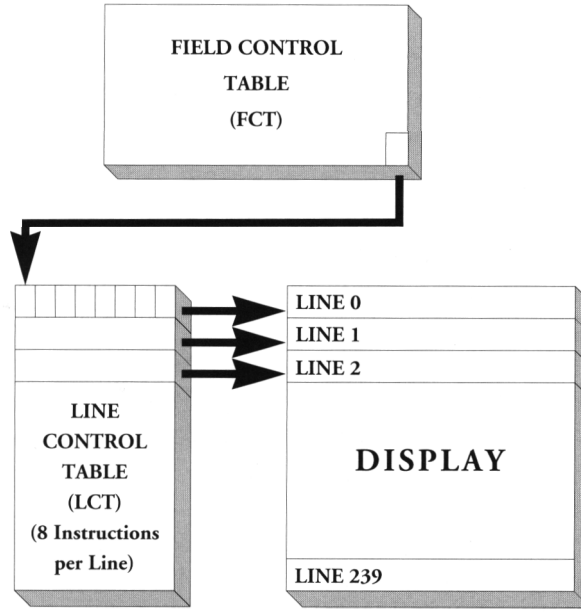



**Figure 27:**
**Display Control Program**

# NON-VOLATILE RAM (NVRAM)

The Non-Volatile RAM File Manager (NRF) is responsible for managing the Non-Volatile RAM of a CD-I player. In creating a file system for the NVRAM, Microware was presented with an interesting challenge as well as opportunity.

The challenge was to make this file system as simple as possible. 8K is not much room for storing files. NRF must be made to use as little overhead as absolutely possible.

The opportunity was that this file system could be fast. Being RAM-based, it was never necessary to make a request to an external storage device. Every file was instantly accessible.

The solution that developed was a single-level file system. You cannot create directories (or folders) on the NVRAM. Also, all files are placed in the NVRAM so that there is never any fragmentation. If a file is deleted, other files are *shuffled up* to fill the gap. If a file is expanded, other files will be *shuffled down* to make room.

NRF itself uses only a few bytes of space at the beginning of the area for keeping track of the valid files and the free block. This leaves almost all of the space available for the application data itself.

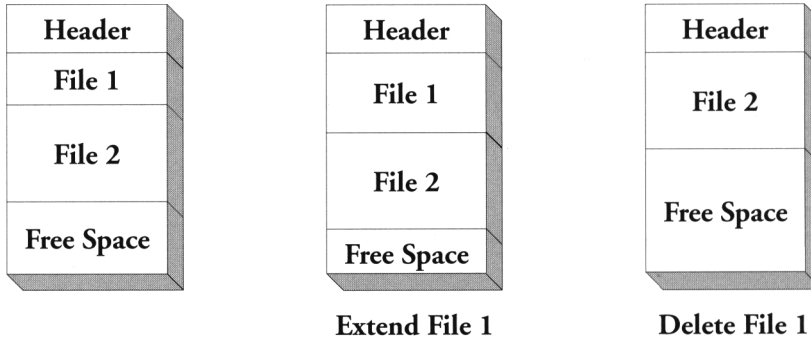



**Figure 28:**
**Map of Non-Volatile RAM**

# PIPES

Pipes are managed in CD-RTOS by the Pipe File Manager (Pipeman). Pipes are a very simple form of interprocess communication and are inherited from OS-9. One process can write into a pipe and another process will read it. In other words, what goes in one end comes out the other. This is an excellent way for independent applications to share information.

One unique aspect of pipes is that you also can create a *named pipe*, or even a *pipe directory*, containing many *pipe files*. As you read from a pipe file, the information disappears. When the pipe file is empty, it disappears. This functionality makes it considerably easier for two applications to *share* a mutual pipe.

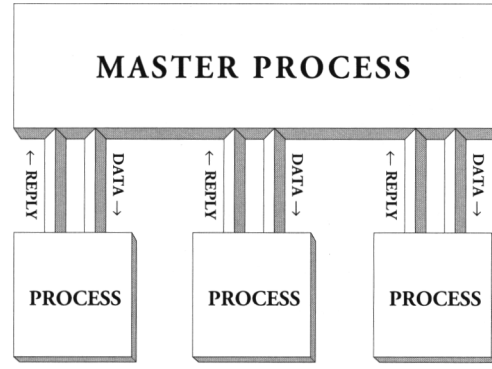



**Figure 29:**
**CD-RTOS Pipes**

# EXTENSIONS

Once CD-I players start to grow, they quickly become home computers. This is when CD-RTOS will really start to shine. Unlike PCs and Macintoshes, CD-RTOS is a full blown, multi-tasking, modular operating system. CD-I players can very easily add serial ports, floppies, hard disks, networks and tape backups. You can add video digitizers, MIDI recording and even telephone connections, right into your home CD-I player.

In this area, CD-RTOS inherits the rich body of software developed for OS-9. OS-9 has been used for nearly fifteen years for everything from automatic teller machines to robots to navigation guidance systems. This software is 100 precent compatible with the CD-I system.

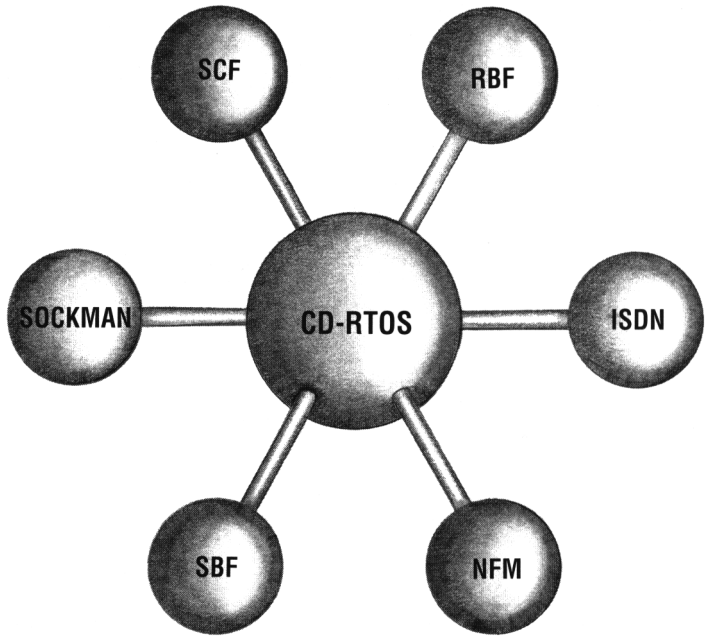



**Figure 30:**
**CD-RTOS Extensions**

# CONFIGURATION STATUS DESCRIPTOR

The Configuration Status Descriptor (CSD) was designed as a mechanism to enhance the portability of applications between different CD-I players. Early on, Microware saw there ultimately would be a wide variety of players available. Some would have two joysticks, others only one. Some would have keyboards, floppy disks or printers. Some would have multi-disc changers. There would have to be some way to communicate this to the application software. Thus, the CSD was born.

The CSD is represented as a file in the Non-Volatile RAM called, appropriately enough, "csd." This file is made up of Device Status Descriptors (DSDs). Each DSD consists of a device type code, the name of the device (used for opening paths to the device) and a list of parameters that describe the device.

The CSD is an ASCII file that can be listed or edited by a word processor. Figure 31 shows an example CSD.

```
0:sys:RV="1.1":
1:/cd:
2:/ap:
3:/vid:LI="525":TV:
4:/nvr:
5:/ptr:CL="d":
5:/ptr1:CL="d":
6:cdp:
8:mon:
9:/pipe:
```

**Figure 31:**
**A CSD File with Two Pointers**

In the example CSD, there is an entry for each device in the system as well as an entry for CD-RTOS itself ("sys:RV="). This entry describes

which version of CD-RTOS is present in the ROMs. In general, it is not recommended to create software that is dependent upon one specific version of the operating system, but it is possible to do so.

In addition, the example CSD has two entries with device type 5. This indicates that this player is equipped with two pointing devices (joysticks, light pens or mice). The 'CL="d"' parameter indicates that they are both relative coordinate maneuvering devices (most likely joysticks).

Although they are not shown here in a base case CSD example, there are also device type codes reserved for terminals, printers, floppy disks, hard disks, Musical Instrument Digital Interface (MIDI), Local Area Networks (LANs) and magnetic tape devices.

Whenever an application needs to open a path to one of these devices, it reads the CSD, looks for the matching device type and gets the name of the device from the appropriate DSD.

♦ NINE ♦

# THE DESIGN PROCESS

## Overview

The following chapters will provide an in-depth analysis of the CD-I title design process, with an emphasis on the staff requirements and job requirements for each. Some of the personnel and techniques used have parallels in the film or video business. Some apply to existing applications in the computer world. Others were invented just for CD-I.

One of the catch phrases in interactive multimedia is *Authoring Systems.* Everybody knows you need one, but nobody can quite agree on what one is. Whenever a group of CD-I engineers gets together to discuss authoring systems, one is reminded of the story of five blind men who are asked to describe an elephant. One feels the trunk and describes something "like a snake." One feels the leg and describes something "like a tree." One feels the ear and so on.

This has led to a situation where there are a good number of *tools* available that each do one thing very well, but no overall Authoring System (capital A, capital S) that fulfills the requirements of a broad range of applications. In all fairness, as this book goes to press, this problem is in the process of being tackled, but the viability of the solution remains to be seen. The bottom line is that, today, you need a software engineer to create most CD-I titles.

Before jumping into the title design process, though, it might be useful to take a brief look at the history of CD-I authoring, to gain perspective on the current state of the art.

# HISTORY

In the beginning, the CD-I community was not overly concerned with the process of *designing* titles. They were mainly concerned with establishing the production pathways; i.e., creating CD-I audio and video, combining it into real-time files and putting it on a disc. At the simplest level, authoring involved four broad steps:

- digitizing the audio and video assets
- creating the application software
- creating and previewing real-time files
- mastering a tape for replication

At that time, a CD-I authoring system was a large multi-processor computer costing $250,000, that did little more than grab audio and video and convert it to CD-I formats. It did, however, have one unique feature. That was the ability to *simulate* the playing of a CD-I disc from a hard disc. Unlike CD-ROM, which is more or less a glorified floppy disk, CD-I includes time-critical audio and video data. The simulator had to buffer the hard disk and produce CD-I sectors with the appropriate headers at very precise rates to some other specialized boards that all together created a *virtual* CD-I player. This system was built almost entirely with custom hardware and software, thus its expense. There were only a handful of them ever made.

Around 1988, though, this began to change. CD-RTOS was starting to solidify and more and more studios were trying to create titles. There was simply no way that the industry could start itself using such expensive machines. Even the second-generation capturing systems cost upwards of $100,000, which really just changed things from astronomically expensive to only incredibly expensive. If CD-I title creation was ever going to be cost effective, you had to be able to work on $5000 to $10,000 systems.

The first step to cost-effective title creation was to incorporate off-the-shelf A/V equipment based on common PCs, Macs and Amigas. These

three systems form the basis for almost all A/V asset production today. The only additional software necessary were the filters to convert these images and audio into CD-I formats. This was a relatively easy, but important, step.

## CD-I Players

One of the most important factors in reducing the cost of authoring was the fact that Philips decided to take the plunge and manufacture a few thousand actual CD-I players. These were distributed with a test disc that showed all of the basic things you could do with CD-I. In doing so, they created an environment where virtually anybody could then experience CD-I first hand.

A CD-I previewing station literally plunged in price from $100,000 to $5000 overnight. This finally made it cost effective for everyone in the production chain to have one—from the artist to the audio engineer to the programmer.

Most importantly, Philips designed these players in such a way that you could remove the CD drive and attach another computer there instead. This led to the second major step in CD-I authoring: emulation.

Several independent companies have since developed emulators based on connections to PCs, Macintoshes and Sun workstations. Most notably among these are OptImage, ISG and Script Systems.

This took care of the hardware end of things. Programmers could develop software with a high degree of confidence that they were looking at the *real thing*. Now the attention of authoring software companies turned to design tools, geared more toward the interactive designers and non-software engineers.

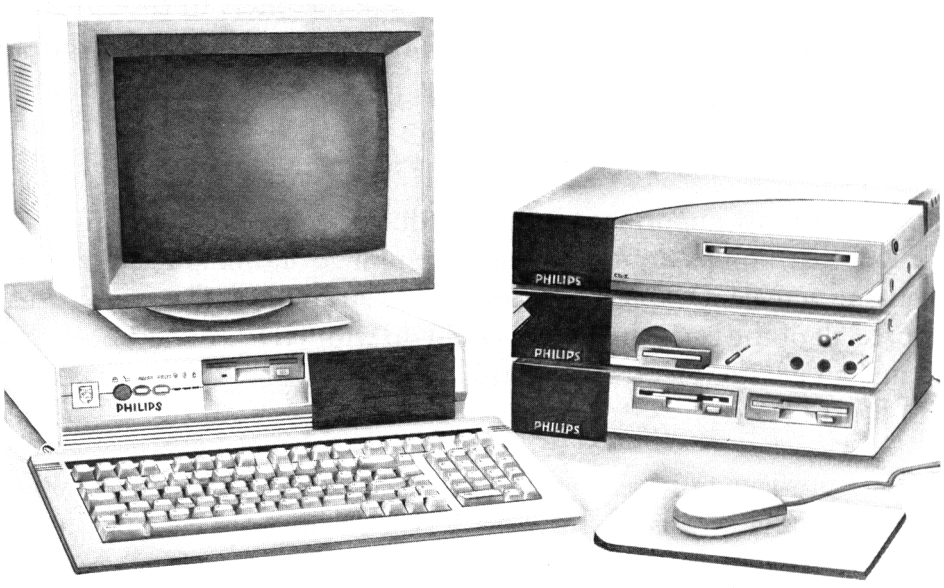



**Figure 32:**
**CD-I 18x with Emulator**

## Starter System

The first piece of software that truly attempted to meet the needs of the CD-I Designer/Producer was the Starter System from OptImage. This product allowed you to browse through a series of images, put some background music with it and specify the special effects that would happen between images (dissolve, left-to-right wipe, cut, etc.). It was more or less a slide show generator, but it could be done largely with a mouse and required no computer programming. It was revolutionary for the CD-I community.

Based on the comments of the CD-I community, this tool grew into a product called Producer, which later evolved into MediaMogul.

Producer allowed you to specify a *hot spot* on the screen, which would respond to a pointer *click*. Based on this user action, a new slide show could be played or a new menu presented. Again, this required only minimal keyboard activity and no knowledge of computer programming.

Once you organized your program with Producer, you could have it generate a master tape for replication. The drawback with Producer was that it was not extendable. You were stuck with the options built into Producer itself. It was an all-or-nothing proposition.

So Producer became MediaMogul. MediaMogul added the ability to branch to subroutines or programs written to customize the application. As well, it added support for animation and transparent text. This finally made for an extremely robust tool for prototyping and, in fact, producing a good number of CD-I titles.

## Today

This brings us more or less to the current state of development. All of the components are in place for CD-I authoring to jump. The next generation of tools will incorporate scripting languages, more advanced animation and title management tools for organizing the hundreds or thousands of files involved in creating a CD-I title. All three compa-

nies—OptImage, ISG and Script Systems—are working on systems to do just that.

Along with the development of advanced title creation tools, we have to address the integration of the other production staff in the design process. The next section will describe how all of these people work together to produce CD-I titles.

♦ TEN ♦

# THE DESIGN PROCESS

## A Step-by-Step Guide

Creating an interactive multi-media presentation can be quite a complex process. Some titles are fairly straightforward, others are extremely involved. In this section we will examine two titles in some depth and discuss how they were produced.

In addition, we will examine the sort of staff you will need to do CD-I production. Of course, the exact requirements of your studio will depend on the type of titles you are going to produce, but this will give you some general guidelines.

The basic steps in producing a title are:

- The Design
  - Writing a Treatment
  - Developing Key Storyboards
  - Designing the Navigation Map
  - Writing a Script
- Prototyping
- Creating and Encoding the Presentation Assets
- Creating Custom Application Programming
- Pre-Mastering and Emulation
- Mastering and Replication

These six basic steps are carried out by a design team that usually consists of several people. In smaller studios, a single person may wear more than one hat, but functionally there are several distinct jobs to be done:

- Interactive Designer
- Technical Director
- Art Director
- Audio Director
- Script Writer/Content Expert
- Media Production Coordinator

Each of these steps will be examined in detail in the context of the person or people responsible.

# The Design

The first step to creating a successful title is having a thorough design. This is naturally the domain of the Interactive Designer. This person, more than any other, is responsible for maintaining the vision of the project and making sure the other people produce things that are appropriate in view of the overall design.

The Interactive Designer also would typically work with the Technical Director, who is responsible for doing a "sanity check" on the title: making sure that the design is possible within the realm of CD-I technology. At this stage he is mainly responsible for making sure that the design doesn't call for seventeen interleaved audio tracks along with Full-Motion Video or 50,000 full-screen RGB images on a single disc.

It is important to keep in mind that the following steps are done in an iterative process. Throughout the project, it may become necessary to go back and revise some of the assumptions about the design embodied in the treatment or navigation maps. It is important to keep track of these changes formally. At first, so that you can learn from your mistakes. Then, to make sure that the software engineers and artists and audio engineers all have the same vision.

Logically, designing the title is divided into several steps.

# TREATMENTS

In simplified terms, a treatment is a description of the title. It specifies:

- The goals of the title (education, entertainment, reference, etc.)
- The audience (adult/teenage, male/female, group/individual)
- The type and availability of audio/video data
- Market feasibility
- Potential roadblocks
- Probable costs for the title

A treatment should give you a good impression of the look and feel of a title, without describing the contents of every menu on every screen. In a sense, this is the feasibility stage of title development.

When writing a treatment you need to answer several questions, most importantly: Who will buy this title? Why? Where will they use it? When will they use it? Will they feel drawn to use it over and over again? A lot of treatments go up in smoke when their authors were forced to answer these simple questions.

The treatment is created by the Interactive Designer. It is checked and approved by the Technical Director.

## STORYBOARDS

Storyboards take you to the next step in describing a title. As the name implies, storyboards actually begin to tell the story of the title. When you storyboard animations, you mock up half a dozen or so key frames to introduce the main characters or objects. When you storyboard an interactive title, you also mock up the key menus or screens that will be presented during the title.

At this point, you need to give thought to the form and location of menus or hot spots. Will menus be text based or image based? Will the options be overlaid on an existing image or will they take up the full screen by themselves? What options are available while video is playing, and what options are only available between videos?

Storyboards may be drawn on paper or using a computer. They may be black-and-white line drawings or fully produced images. Typically, they are kept simple until the later prototyping stages. They may undergo several revisions, so it is a good idea not to put too much work into the finishing details.

Eventually, though, it is a good idea to mock them up with actual CD-I images to use as "place-holders" for the script writers and programmers to come.

Storyboards may be drawn by the Interactive Designer or the Art Director for the title (usually they both work closely together at this stage). Again, they are primarily for key frames and menus. Figure 33 shows some examples from the "Listening Booth" title.

1
CATEGORY MENU
Pop/Rock
Soul/Dance
Hard Rock
Jazz
Country
Other
JUKE BOX
SHOP STOP
Category Menu - Select music category, Juke Box or Shop Stop. After 10 seconds, prompt user to make a choice.
2
ARTIST- ALBUM NAME
Track #1
Track #2
Track #3
New Category
Next Album
Album Menu - Select a song for playing or lead to next album. Circular list for each category. Choosing the song title will play music video.
3
ARTIST- ALBUM NAME
New Category
Next Album
Video - While video is playing, stop it by selecting New Category or Next Album.
4
ARTIST- ALBUM NAME
New Category
Next Album
Video - While video is playing, stop it by selecting New Category or Next Album.
5
How did you like this track?
A lot
A little
Not at all
Display this screen and record the response after every song is played (even if it is aborted).

**Figure 33:**
**Storyboard Example from "Listening Booth"**

## Navigation Maps

This is the first stage of the title design process where very specific decisions must be made about the interactivity available in a title. At this stage, you start to specify the actual decision-making trees that determine the flow of a title.

Navigation maps are simplified forms of the good old flowchart, although not with nearly the same detail or formality. The Navigation Map simply says, "at this point, you are presented with five options, three of them will play a slide show, one will return you to the previous menu and one will quit the title."

Navigation Maps are typically the product of the Interactive Designer working with the Content Expert. The Content Expert is the person who best knows the subject matter of the title, what options should be available and why. Figure 34 shows an example Navigation Map, again from "Listening Booth."

In this example, the user is presented with a menu, asking the user to select from the categories "Jazz," "Pop" or "Country." The diamond shape is used in this map to indicate that a choice is required. If, for example, the user selects Jazz, he or she is presented with a second menu that shows an example Jazz album.

At this point, the user may select one of three songs from this album, look at another Jazz album, or select a new category of music. Selecting one of the songs will play a music video and record the user's reaction ("Like," "Didn't Like," "No Opinion").

The square symbol is used to represent a piece of video (or series of stills). The triangle is used as a sort of "go to" symbol. In this example, the option to select a new category of music would result in a "go to" point 1 (the category menu).

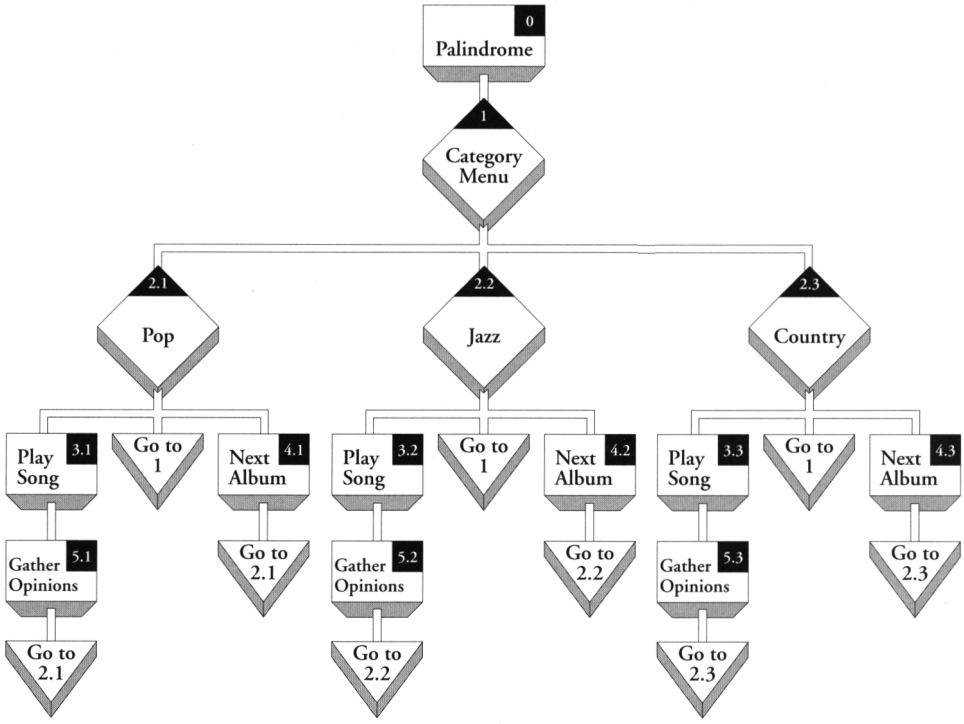



**Figure 34:**
**Example Navigation Map from "Listening Booth"**

Notice that each symbol on the map is numbered. This helps to refer to the symbols and to identify repeating sets of symbols that can be grouped into common structures.

Accompanying the Navigation Map is a detailed description of each symbol on the map. This gives, for example, the list of presentation assets that are necessary at that point in the title, the location of any hot spots and the results of interacting with a hot spot on that screen. Again, Figure 35 shows an example from "Listening Booth."

| | |
|---|---|
| Node 0: | PALINDROME |
| Desc.: | Palindromic series of 4 screens to attract user and invite him to begin using disc. |
| Video: | DYUV images resident in memory. [TRANSITIONS: HORIZ. BLINDS EVERY FEW SECONDS.] |
| Audio: | Confirming touch "beep." |
| Node 1: | CATEGORY MENU |
| Desc.: | This Menu presents 3 music categories. |
| Video: | (DYUV) Menu listing of music categories. |
| Audio: | After :10, prompt invites user to touch the screen. |
| Branching: | Go to designated album for each category. |
| Node 2.1: | ALBUM #N |
| Desc.: | This is the first album in a category (as described above). The user either elects to listen to some tracks or look at another album. Choosing "Next Album" moves you around the ring. |
| Video: | Appropriate album cover. |
| Audio: | After :10, prompt encourages user to make a selection. |
| Branching: | Track Selection (Node 3.1), back to Category Menu (Node 1), or on to next album. [TRANSITION TO THE n3.1 LEVEL FROM n2.1 LEVEL WILL BE A HORIZ. CURTAIN.] |

**Figure 35:**
**Example Node Description Map from "Listening Booth "**

Needless to say, the Technical Director periodically reviews these specs again to make sure that what is required is in the realm of the possible, adjusting the Navigation Maps and Descriptions as necessary.

# SCRIPTING

Scripting really covers two separate areas. In the classical sense, scripting involves writing the narration for a title. This is still the case. The difference between writing the script for a TV show or movie and a CD-I title is that TV is linear and CD-I is not. When writing a TV script, you always know what the listener has already heard.

In CD-I, the user often will jump around, seeing a piece of this and a piece of that. This forces the script writer to re-evaluate the process of describing something. It sometimes can even cause the Interactive Designer to go back and modify decisions about which portions of the title can be reached from which other points. This script writer is typically the Content Expert, perhaps working in conjunction with a professional writer.

The second aspect of scripting involves scripting the video, i.e., detailing the list of images or video, the transitions between images and the use of special video effects. Often this "shot-sheet" will be integrated directly with the narration script, as they are often intertwined.

This gives the Media Producer an idea of what he or she will need to do to assemble the Presentation Assets. Will live video have to be shot? Will the still images need to be photographed or will they be available from archives? Will an artist need to generate several hundred graphs? And so on.

PROJECT: MICROWARE ORIENTATION

REVISION: A

NODE: 3.1.1

| Time Code | Video | Narration |
|---|---|---|
| 00:03:00 | Outside shot of Microware building | As Microware continued to grow, they moved to their current location at 1900 114th St. |
| 00:09:00 | Dissolve to programmer's office | This new environment created the proper conditions for their highly creative work to take place. |
| 00:12:00 | Dissolve to empty kitchen | Of course, everyone's favorite room is the kitchen. |
| 00:16:00 | Dissolve to several people eating lunch | This is where many of their best ideas are created. |

**Figure 36:**
**Example Scripts**

## PROTOTYPING

As the Navigation Maps are completed and the scripting begins, the Title Design team begins working on prototyping the application. The Art Director begins to create the screen mock-ups of the storyboards and other key frames to test the ideas in a more realistic environment. There are many tools for helping in this regard. Virtually every type of computer used for CD-I authoring (Amiga, Macintosh, PC and the CD-I player itself) has a program for prototyping interactive multimedia presentations. Among the more well-known programs are AmigaVision and Can Do for the Amiga, MacroMind Director and HyperCard for the Mac, and MediaMogul for CD-I.

Each of these tools has a lot of value and, to be honest, if you are a disciple in the religion of Macintosh, Amiga or PC, there is little value in trying to convince you to use a different system. You will be able to use all of these systems for adequate prototyping. If, on the other hand, you are slightly agnostic (like myself) and don't subscribe to one of the above faiths, you might consider using the CD-I player itself for your prototyping system.

Using a CD-I player connected to a hard disk or network for storing audio and video assets has several advantages to using non-CD-I systems. Most importantly, it is "WYSIWYG" (What You See Is What You Get). If you create a video image, it will be the correct resolution and aspect ratio. If you encode some sample audio, it will be the same audio that you will hear on the final production disc. The importance of this cannot be understated.

By far the best program to date for prototyping applications on CD-I players is MediaMogul from OptImage. Although it may be limited as a full title production tool, it is unparalleled for rapid prototyping. With MediaMogul you can paste together images and text, create new images, identify hot spots with the mouse and implement the basic connections described by the Navigation Map. If your title has only very simple interaction, MediaMogul can, in fact, go the whole nine yards, even creating

a master disc image suitable for pressing into a CD or for making a CD-WO (Write Once) disc using a system like the Yamaha PDS.

The user interface for MediaMogul was designed not for programmers, but for Interactive Designers. It is operated almost entirely with a mouse instead of a keyboard and requires no knowledge of CD-I hardware or programming practices. Audio and video cues are based on time codes similar to those used in video editing (minutes:seconds:frames) with an editor reminiscent of a spreadsheet.

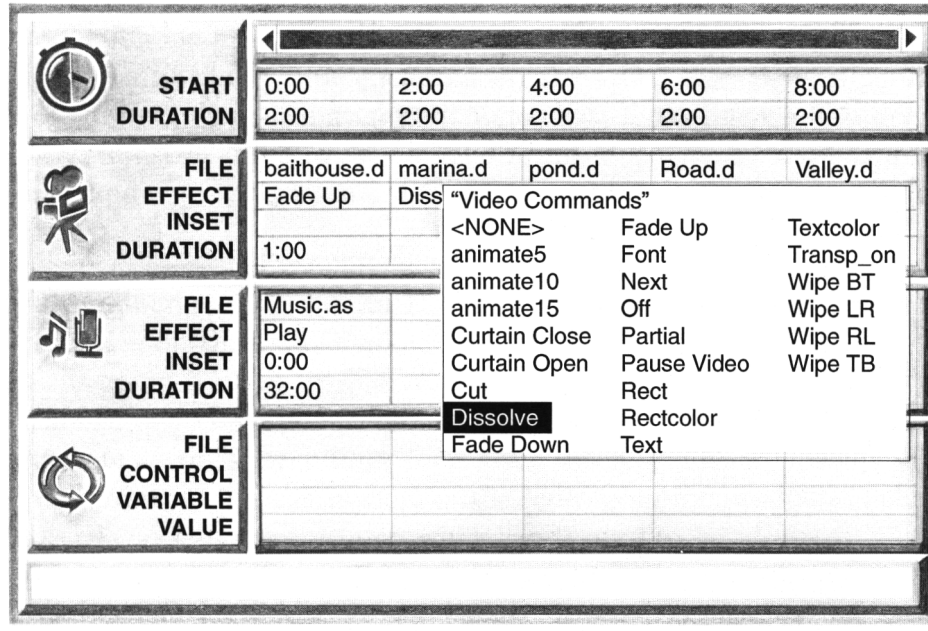



**Figure 37:**
**MediaMogul Screen with Pulldown of Effects Menu**

Also very important for CD-I, MediaMogul will let you know if the title you are creating actually will work from a Compact Disc, as well as from a hard disk. This constraint analysis is a very important part of the prototyping process and is not available from any other hardware/software platform.

The drawbacks of MediaMogul are that it does not handle audio channel switching, text file browsing or other complex interactions based on mouse clicks. ("I want my buttons to spin clockwise when the pointer enters the hot spot region and counter-clockwise when the pointer button is depressed.") These types of limitation draw a sort of "line-in-the-sand," beyond which you will need to rely on your Technical Director for advanced programming.

# Creating and Encoding Presentation Assets

Now we come to the real meat of a CD-I title. The audio and video elements that make up a CD-I title are collectively called the *presentation assets* or PAs. It is the responsibility of the Art (or Video) Director to create the final visual assets for the title and the responsibility of the Audio Director to create the final aural assets for the title.

Both of these people subsequently funnel their work through the Media Production Coordinator. This person is responsible for converting the 35mm slides and videotape into CD-I format digital video. Likewise, the Production Coordinator will take the master audio tape and convert it to digital audio suitable for encoding on the CD-I disc. This is actually more difficult than it may sound. Video that looks fine on film doesn't always translate well into the digital domain. Likewise, a paint box image created on your Macintosh or PC may not look nearly as good on a CD-I player.

The Production Coordinator is responsible for maintaining the quality of the PAs on their way through the production chain. Sometimes this means going back to work with the artists to educate them as to what makes a good CD-I image. Sometimes this just means choosing the appropriate encoding technique for a given image. Audio is typically more straightforward but can involve further editing in the production chain, especially at lead-ins or trailers where levels need to be adjusted.

## Creating CD-I Video

When creating video for CD-I, there are many options available. Each has strengths and weaknesses depending on the source material. Video elements may come from flat art, slides, transparencies, videotape or film. Further video may have to be generated on a computer using a drawing program. Again there are religious issues involved in recommending one system over another, but there are several points that are important to consider when putting a video production system together:

- Always work with CD-I resolutions and aspect ratios. If your paint box creates images 512x512, they look funny when you

convert them to 384x240. If possible, create images in 384x240 or 768x480 (384x280 or 768x560 for PAL format images).

- Make sure that you consider networking. Unless you do your video capturing and encoding, audio capturing and encoding, disc building and emulation all using the same computer, you will need to transport large amounts of data between systems. Ethernet is the most common and portable connection. It is commonly used to connect Sun workstations, CD-I players, Macintoshes, PCs and Amigas. In many ways, the network is the backbone of the studio environment.
- Consider the availability of fonts. Broadcast fonts will give much better results than computer or print fonts. Avoid fonts with heavy serifs or italics. While they may be acceptable in larger type sizes when viewing in RGB, they are generally unacceptable when viewed in composite mode.
- Check the availability of scanners for your system and software to control them, as well as software for controlling video tape systems.

You can find these features in an Amiga-, PC- or Macintosh-based system. Price of hardware and software likely will be the primary differences. One may do animation better. Another may have better scanner software. You may simply be more comfortable with one system or another.

When you begin creating video for CD-I, you will have another set of concerns:

- Work with CD-I color depth. If you plan to do complex animations, remember that normal resolution run length encoding (RL7) supports only 128 colors. Double resolution run length (RL3) supports only eight colors. If you need more, consider putting the complex colors in a DYUV background image and animating figures in the foreground with fewer colors.

  For still images, CLUT8 supports 256 colors from a palette of 32,767 while DYUV supports a much greater number of colors.

Text will look better in CLUT modes while natural images generally look better in DYUV.

- Remember to check the image quality in Composite as well as RGB. CD-I developers typically do most of their work using the RGB outputs on the CD-I player. The reason is simple: It looks better. You must, however, keep your audience in mind. The vast majority of home TV sets don't accept RGB input and composite mode tends to make images bleed. Text can become practically unreadable unless attention is paid to anti-aliasing or the use of drop shadows. Oversaturation of the image, acceptable in RGB, can also seriously degrade the image in composite, making the colors look muddy.

## Creating CD-I Audio

The audio production chain is slightly different than the video chain. Audio will come in to the CD-I studio in one of two forms: analog or digital. If it is analog, you convert it to digital and then encode it. If it is already digital, you basically just have to encode it to ADPCM. By far the most common system used for digital audio editing is Sound Tools by Digi-Design running on a Macintosh. Sound Tools supports analog as well as digital audio input and has a very nice digital editor. Software is available from OptImage that converts the audio directly to CD-I quality ADPCM audio on the Mac.

## Creating Real-Time Files

Once all of the audio and video assets are assembled, the Media Production Coordinator, along with the Interactive Designer and Technical Director, begin to create the Real-Time Files (RTFs) for the title. Using a tool such as MediaMogul, they would decide when each image should appear and which effect should be used in the transition. MediaMogul would find out how large the various assets are and place them in the RTF so that it could be played by CD-RTOS and the various assets would arrive at the appropriate time.

MediaMogul, on the other hand, will not be able to build every RTF that you need to build. At this point, you will need to use a lower level script-

ing tool like Master, also a product of OptImage. Master builds RTFs (and subsequent complete disc images) from scripts that look like this:

```
    record
real_time audio in channel 1 from
    "adpcm:intro.acm"
video in channel 1 from
    "slides:pic1.d" [dyuv] from 00:04:00,
    "slides:pic2.d" [dyuv] from 00:07:30,
    "slides:pic3.d" [dyuv] from 00:08:30,
    "slides:pic4.d" [dyuv] from 00:12:00,
    "slides:pic5.d" [dyuv] from 00:16:00,
    "slides:pic6.d" [dyuv] from 00:18:00
```

Using Master you can interleave audio *streams* for real-time switching and directly set Trigger, EOR and other bits. It is usually the Technical Director who deals with designing and creating these more complex RTFs.

## Custom Application Program Integration

This is one of the final steps in creating a CD-I title, and is, in many ways, the most difficult. It is certainly the most difficult area of title development to automate. In this stage, you have to supply all of the custom programming to make the buttons spin and the lights light up. This is the domain of the Technical Director.

To this date, all CD-I programs have been written in a language called "C." It is a rather low-level programming language developed by AT&T Bell Labs in the late '70s. While C is well suited for real-time programming, it is fairly esoteric in its syntax and it takes quite a bit of training for programmers to write CD-I applications using this language.

To help with this, several companies have offered libraries of functions to hide the intricacies of CD-RTOS and the CD-I hardware. Most significantly among these are RAVE (Real-Time Audio/Video Environment), a product of Microware Systems Corporation and Thomson Consumer Electronics, and BALBOA, a product of Philips and OptImage.

RAVE and BALBOA are fairly similar in that they provide a simpler interface to the complex structures of CD-RTOS. Since some of the same people were involved in the design of these two products they share many traits. On the other hand, they were designed for different purposes and audiences, which influences other aspects of their design.

Ultimately, both RAVE and BALBOA should be replaced by an even higher-level language called a *scripting* language. This language would be more like common English and would be *interpreted* directly, instead of compiled into machine code. An example might be:

```
Load Image1
Load Image2
Load Image3
Show Image1
Activate HotSpot1
Activate HotSpot2
Wait for Button Down
```

```
If Mouse in HotSpot1 then Dissolve to Image2
Else Dissolve to Image3
```

Once this type of language becomes available for CD-I, it will be possible for designers or producers to actually write CD-I programs. Until that time, programs will be written by programmers using products such as RAVE and BALBOA.

## Pre-Mastering and Emulation

Pre-mastering refers to the process of combining all of the Real-Time Files, normal text/data files and application code into a "disc image." This disc image is a virtual compact disc residing on a hard disk. This includes all of the Disc Label sectors, the CD-I Path Table and other data structures described in the sections on CD Basics and CDFM.

This disc image is used by an emulator to make the final tests on the title before pressing. As mentioned previously, Philips created a CD-I player with a removable CD Drive. By unplugging the drive and plugging in another computer to the port, you can fool the CD-I system into thinking that there is a Compact Disc out there. The second computer waits for a command such as Seek, Read, Pause or Continue and sends data to the CD-I system at the correct rate.

By actually emulating the drive in every respect, including approximating the time that it takes to seek from the inside of a CD to the outside, you can test not only the Real-Time Files but also the response time of the application. If it takes too long to find a file on the disc, it is possible to optimize the image by moving two files closer together. Similarly, you may be able to load four images from a hard disk in a second, but only 1 1/2 images from a CD. This sort of testing can only be done on a CD-I player with an emulator.

There are two emulator systems currently available, one from OptImage and one from ISG. The ISG emulator is a plug-in board for the Macintosh or Sun SPARCstation. It comes with a set of programs for building a CD image on the Mac/Sun, both from a graphic interface as well as a scripting interface, and another program for handling the emulation.

The OptImage emulator is a stand-alone single-board computer system from a company called GMX. It runs OS-9 and can use an internal hard disk or connect via SCSI to a Macintosh, SUN or PC hard disk. The CD image is created by the Sun, PC or Mac from files anywhere on the network. The GMX system acts as a data buffer and digital hardware interface.

Both of these systems will support building the image to an EXABYTE or nine-track tape for replication at a pressing plant. Which brings up the final stage in title development.

## Mastering and Replication

Mastering the CD refers to a process that typically takes place at a Compact Disc pressing facility. CD-I discs are made by the same machines that make CD-DA and CD-ROM discs. By taking advantage of these common facilities, it is possible to greatly reduce the cost of replication. CDs cost an average of $1 apiece in volume.

It is also possible, though, to make individual copies of a CD through a process called CD-WO or WORM (Write Once Read Multiple). Yamaha has developed a system called PDS that burns a CD from a blank master. By connecting your emulator to the PDS, you essentially transfer the image directly to the CD. For quick demos or for making a few copies, these systems are invaluable. When making more than about 20, though, the economics degrade rapidly.

When pressing a disc at a replication factory, there is a one-time fee for creating a master form for the replication process, and a per-disc fee based on how many copies are being made. The set-up fee is typically between $1000 and $2000, depending on how fast you need the discs. The per-disc fee is $1 to $3, depending upon quantities.

Most facilities will give two- to three-week turnarounds for small orders (under 1000 pieces) and some will even promise a three-day turnaround for a premium.

# MAKING THE DECISION

♦ ELEVEN ♦

# MAKING DECISIONS

## What does CD-I cost?

By now, you should have a fairly complete idea of what CD-I can do and what its future looks like as well as the technical aspects of CD-I and the requirements to become involved in CD-I publishing. This chapter ties together the information presented in this book and guides you through some sample studio set-ups for small-, medium- or large-scale operations.

There are two critically related areas that must be considered: staff requirements and hardware/software requirements. These may be tied in turn to many things—for instance, your long-range strategic goals or even your specific physical company space for CD-I publishing.

While we can't know what individual needs you might have, we can outline the basic staff requirements and hardware/software requirements for three example studios. Your actual costs will vary greatly, depending on how much equipment and infrastructure you already have in place, as well as local pricing and services.

# STAFF REQUIREMENTS

## The Small Studio

A CD-I studio can be started with a fairly small number of people, primarily by sub-contracting the more difficult or expensive portions of the production process. The core group would consist of an Interactive Designer, a graphic artist and one or two programmers.

Any audio work could be subcontracted to a local recording studio who would supply a master tape for encoding. The encoding could be done by any one of the staff familiar with a Macintosh and SoundTools or could also be subcontracted to another larger CD-I studio.

The work of the Media Production Coordinator also would typically be split between the various staff members, with the designer and artist doing the video encoding and the programmers building the Real-Time Files.

This type of studio works well for small productions or situations where the actual volume of titles is not large.

## The Middle-Sized Studio

As you start to work on more than one title at a time, you will need to add staff in a few critical areas.

The first person to add is your Media Production Coordinator. This person typically acts to coordinate the production of the various audio and video elements that make up the titles, as well as scheduling the use of the larger central computer systems for doing batch processing of the audio and video.

This size of studio typically will still not have a professional audio suite, although they will do all of their encoding in-house. The Media Production Coordinator often will handle this job as well.

Secondly, you will need to add another programmer. Unless you are doing "cookie-cutter" type titles, a good rule of thumb is to have one programmer per title, plus one programmer who is available for writing special programs or subroutines that all of the titles will use. An example of a cookie-cutter title is a children's book. The second book will probably not involve any new program code; only the pictures and text will change.

Estimating the number of artists necessary is somewhat difficult. It is highly dependent upon the type of titles being done. Some titles will need only a dozen unique images for menus. The rest of the images would be taken from existing artwork and photographs or be created by the program itself.

Other titles may involve hundreds of unique frames or animations where the frame count could number in the thousands. In the first case, one artist may be able to handle several concurrent titles. In the latter case, you may need half a dozen artists for each title. The middle-sized studio will have to deal with this issue.

## The Large Studio

As the amount and complexity of your equipment grows, most studios find it necessary to include a hardware engineer to maintain the miles of audio and video cable in the studio. When you notice noise in the signal or a system breaks down, this person is suddenly your best friend in the world.

Hand-in-hand with this person is a system administrator. By the time that you get a dozen or more computers on a network, especially if you are using UNIX workstations, the issues of software maintenance and distribution can become quite a task in and of themselves. Installing new hard disks, connecting new systems on the network and doing the daily backups can take a considerable amount of time away from people who should be working on the titles themselves.

Although these people do not show up on the credits of any given title, they are often crucial to getting every title out the door.

At this stage, you also will need to consider having several producers on staff. You may not need one for each title, but only rarely could a single person handle more than two titles at a time.

Also, you will want to beef up the programming staff. Instead of just one programmer who is working on non-title specific code, you will probably need two or even three, depending on how large you grow. These programmers are sometimes called *Tool Engineers* since they provide the programming tools by which the other programmers are able to get their tasks accomplished.

As authoring systems become more robust and your internal libraries of specialized code become more flexible, programmers will tend to be replaced by interactive designers. Although this probably will not be the case for a few more years, it is ironic that a programmer's main task is to create a program so good that it puts the programmer out of a job.

Finally, it becomes feasible to add a dedicated audio engineer. This person would be responsible for recording narrations and soundtracks or working with an external studio to do so. Additionally, this person would be responsible for encoding all of the audio assets used in a title.

# HARDWARE REQUIREMENTS

The most important and basic element of your studio is also the most obvious; a CD-I player. Every person who is working in your studio should have one on their desk. Programmers will need them to develop their software. Producers will need them to design and prototype applications. Artists will need them to preview images as they create them. Even administrators will often need a player available for title demonstrations.

The player configurations, however, will differ. Programmers will use their players in conjunction with an emulator and development station. In this context, there is some variation as to actual setups.

In the simplest scenario, the emulator is the development station. The CD-I player and emulator would share a hard disk and the emulator would use Ethernet to connect to other machines in the studio. Software development and disc building could be done on the emulator directly.

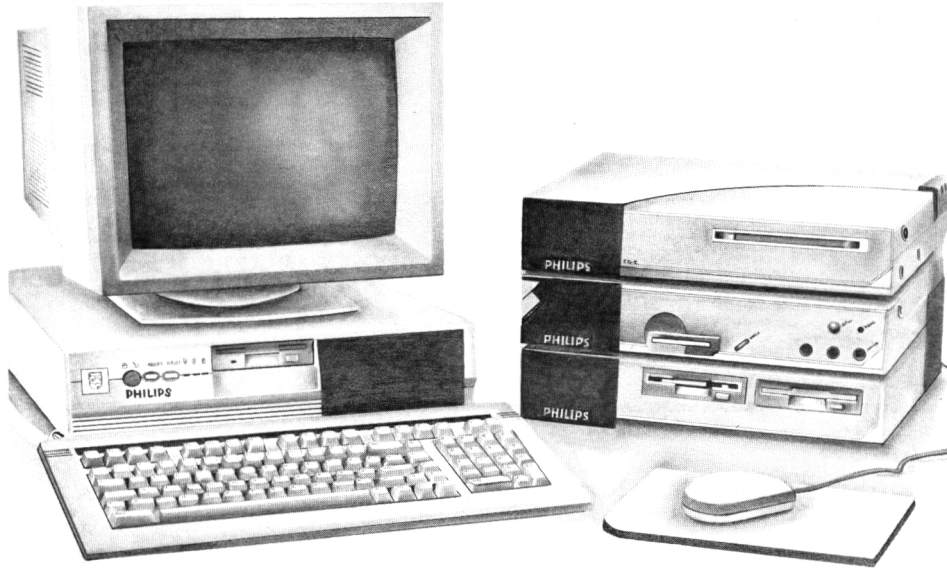



**Figure 38:**
**A Stand-Alone Emulator**

In the second scenario, the emulator would be simply a data gateway to a Macintosh or Sun. In this case, the emulator and Mac/Sun would share the hard disk. The Mac/Sun would have the Ethernet connection and the player would have only a floppy disk. Software development and disc building would be done on the Mac/Sun using cross-compilers to generate programs that could be downloaded to the player.

This scenario takes advantage of the windowing capabilities of the Mac/Sun, but leaves the player without a hard disk. Of course, you can buy an extra hard disk or an Ethernet interface for the player, but this adds quite a bit to the bottom-line cost of the player.

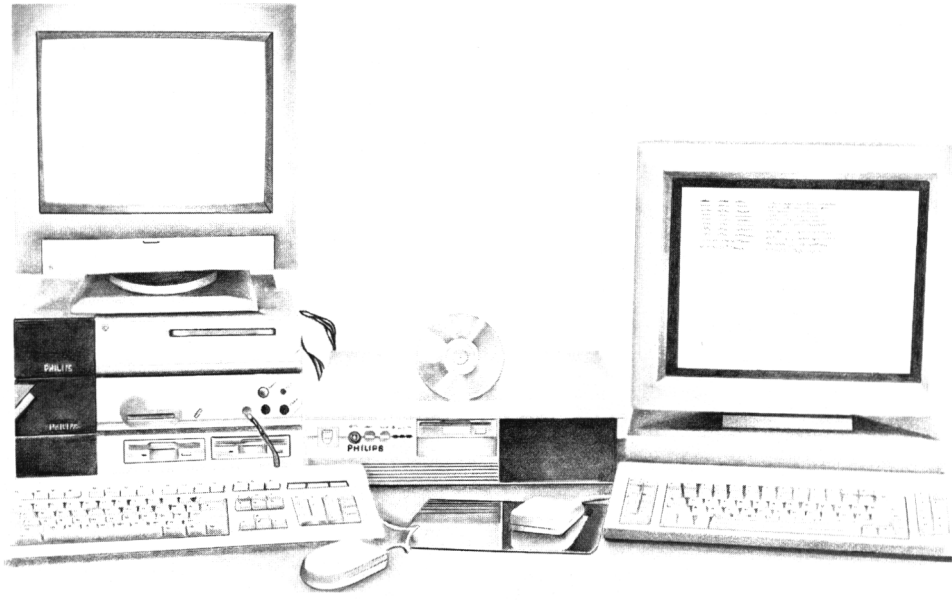



**Figure 39:**
**A Sun Emulator System**

Producers will tend to use their players as stand-alone units typically running software such as MediaMogul. In this configuration, the player would have its own hard disk as well as Ethernet connections. Often,

these stations also will add a tape backup drive or removable hard disk cartridge for importing large numbers of images or audio.

### Audio

If you are doing any audio encoding, a Macintosh with SoundTools will be by far the most cost-effective investment. SoundTools, from DigiDesign, can accept both analog and digital inputs and will convert the audio to CD-I format ADPCM at any of the possible audio levels. In addition, it has some very friendly editing tools, which let you clean up or mix the audio, all in the digital realm.

Along with the Macintosh, you ultimately will need a professional reel-to-reel tape deck or even a DAT (Digital Audio Tape) for importing audio. More and more audio studios are using DATs for final mixdowns so that they don't suffer the generation losses inherent in traditional analog tapes.

Larger studios also will want to build recording booths for recording narrations or soundtracks directly in the studio. This can involve quite an expense, but when the volume of work becomes large enough, it quickly pays for itself.

### Video

Video work can be done on an Amiga, Macintosh or PC. The Amiga is nice in that it supports a video resolution of 768x480 directly. You do not need to buy an additional graphics board. One of the better software packages for the Amiga is Deluxe Paint. It can do stills or animations. For frame grabbing and 3-D modeling, there is a new product called the Video Toaster that is becoming quite popular.

The Macintosh also supports a wide variety of software packages but requires an additional graphics card such as the NuVista or RasterOps boards. For software, one outstanding choice is Adobe PhotoShop. The strength of PhotoShop is that with the addition of OptImage's *plug-ins,* it converts RGB images directly into all CD-I formats and resolutions. For animation, there are, again, many choices. One of the more popular packages is MacroMind Director.

The PC also requires an additional plug-in card to support CD-I resolutions. The card of choice so far has been the Vista running Tips or RIO software. For animation, there are many packages including Animator and Topaz.

Once you have created the images you like, you will need to encode them into CD-I formats. There are utilities available on each of these platforms for changing the local formats (TIFF, PICT, TGA) into CD-I formats (IFF).

As your studio grows, and the number of images to be processed grows proportionally, it becomes more feasible to look at Sun workstations for batch encoding of the images. A Sun may do the job ten or even 100 times faster than equivalent conversion programs running on a Macintosh or PC.

For importing images, even small studios likely will need a flatbed scanner for transparencies and photographs. Some scanners also will process 35mm slides. Others will not. Scanners can cost anywhere from $5000 to $200,000. You probably will not want the cheapest one or the most expensive one, but on the other hand, good-quality scanners are becoming significantly less expensive.

If you are working with motion video, either full- or partial-screen, you will need a videotape deck and Sun workstation with an Androx card. Small studios should start with Beta SP. Larger studios will add D1 or D2 decks as well.

### Miscellaneous

As your studio grows, you also will add video switchers and routers, a preview suite and a number of RGB and composite monitors. It is good to look at video material on several different brands and quality levels of monitors/TVs. The images you see on professional RGB monitors often bear little resemblance to the output of a cheap TV. And there are a lot more cheap TVs in people's homes than professional monitors.

# CONCLUSIONS

The bottom line is that it is not necessarily cheap to get into CD-I. But, on the other hand, it doesn't need to cost a million dollars to make an initial investment. The difference between publishing software for CD-I and publishing software for other computer platforms is the potential size of the market.

The number of sales needed for a product to be deemed successful in the computer world would seem like a dismal failure for consumer electronics. Conversely, even moderate sales in the consumer electronics arena seems astronomical by computer software standards. The payback period, therefore, can be considerably quicker.

# APPENDICES

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# APPENDIX A

## CD-RTOS System Calls

### Terminal Emulation Functions

| | |
|---|---|
| *co_afnt()* | Activate font |
| *co_cod()* | Set character output drawmap |
| *co_dfnt()* | Deactivate font |
| *co_scmm()* | Set character code mapping method |
| *crt_cdwn()* | Cursor down |
| *crt_ceol()* | Clear to end-of-line |
| *crt_ceos()* | Clear to end-of-screen |
| *crt_clft()* | Cursor left |
| *crt_cr()* | Carriage return |
| *crt_crght()* | Cursor right |
| *crt_cscrn()* | Clear screen |
| *crt_cup()* | Cursor up |
| *crt_curxy()* | Cursor address |
| *crt_dchar()* | Delete character |
| *crt_dlin()* | Delete line |
| *crt_hidcur()* | Hide cursor |
| *crt_home()* | Cursor home |
| *crt_ichar()* | Insert character |
| *crt_ilin()* | Insert line |
| *crt_revoff()* | End reverse video |
| *crt_revon()* | Start reverse video |
| *crt_shwcur()* | Show cursor |
| *crt_ulon()* | Start underlining |
| *crt_uloff()* | End underlining |

| | |
|---|---|
| *crt_wrapoff()* | Turn off auto-wrap mode |
| *crt_wrapon()* | Turn on auto-wrap mode |

## Display Control Program Functions

| | |
|---|---|
| *dc_crfct()* | Create Field Control Table |
| *dc_crlct()* | Create Line Control Table |
| *dc_dlfct()* | Delete Field Control Table |
| *dc_dllct()* | Delete Line Control Table |
| *dc_exec()* | Execute display control program |
| *dc_flnk()* | Link Line Control Table to Field Control Table |
| *dc_intl()* | Set display interlace mode |
| *dc_llnk()* | Link Line Control Table to Line Control Table |
| *dc_nop()* | Write array of no operation instructions to LCT |
| *dc_prdlct()* | Physical read of Line Control Table columns |
| *dc_pwrlct()* | Physical write to Line Control Table columns |
| *dc_rdfct()* | Read Field Control Table |
| *dc_rdfi()* | Read Field Control Table instruction |
| *dc_rdlct()* | Read Line Control Table columns |
| *dc_rdli()* | Read Line Control Table instruction |
| *dc_relea()* | Release pending signal request |
| *dc_setcmp()* | Set compatibility mode |
| *dc_ssig()* | Send signal on video interrupt |
| *dc_wrfi()* | Write Field Control Table instruction |
| *dc_wrfct()* | Write Field Control Table |
| *dc_wrlct()* | Write Line Control Table columns |
| *dc_wrli()* | Write Line Control Table instruction |

## Drawmap Functions

| | |
|---|---|
| *dm_close()* | Close drawmap |
| *dm_cncl()* | Conceal error |
| *dm_copy()* | Copy drawmap to drawmap |
| *dm_creat()* | Create drawmap |
| *dm_create()* | Create drawmap |
| *dm_dup()* | Duplicate drawmap |
| *dm_dupe()* | Duplicate drawmap |

| | |
|---|---|
| *dm_exch()* | Exchange data between drawmaps |
| *dm_irwr()* | Irregular write to drawmap |
| *dm_org()* | Set drawing origin |
| *dm_rdpix()* | Read single pixel from drawmap |
| *dm_read()* | Read from drawmap |
| *dm_tcopy()* | Copy drawmap to drawmap with transparency check |
| *dm_texch()* | Exchange data between drawmaps with transparency check |
| *dm_write()* | Write to drawmap |
| *dm_wrpix()* | Write single pixel to drawmap |

## Drawing Parameter Functions

| | |
|---|---|
| *dp_afnt()* | Activate font |
| *dp_clip()* | Set clipping region |
| *dp_dfnt()* | Deactivate font |
| *dp_gfnt()* | Get font |
| *dp_paln()* | Set pattern alignment |
| *dp_pnsz()* | Set pen size |
| *dp_pstyl()* | Set pen style |
| *dp_ptn()* | Set drawing pattern |
| *dp_rfnt()* | Release font |
| *dp_scmm()* | Set character code mapping method |
| *dp_scr()* | Set color register |
| *dp_tcol()* | Set transparency color |

## Drawing Functions

| | |
|---|---|
| *dr_bfil()* | Fill a bounded area with a pattern |
| *dr_carc()* | Draw a circular arc |
| *dr_circ()* | Draw a circle |
| *dr_copy()* | Copy data from drawmap to drawmap |
| *dr_cwdg()* | Draw a circular wedge |
| *dr_dot()* | Draw a dot |
| *dr_drgn()* | Draw a region |
| *dr_earc()* | Draw an elliptical arc |

| | |
|---|---|
| *dr_elps()* | Draw an ellipse |
| *dr_erect()* | Draw an elliptical rectangle |
| *dr_ewdg()* | Draw an elliptical wedge |
| *dr_ffil()* | Flood fill |
| *dr_jtxt()* | Output justified text |
| *dr_line()* | Draw a line |
| *dr_pgon()* | Draw a polygon |
| *dr_plin()* | Draw a polyline |
| *dr_rect()* | Draw a rectangle |
| *dr_text()* | Output graphics text |

## Graphic Cursor Functions

| | |
|---|---|
| *gc_blnk()* | Set cursor blink rate |
| *gc_col()* | Set cursor color |
| *gc_hide()* | Hide cursor |
| *gc_org()* | Set Graphic cursor origin |
| *gc_pos()* | Position cursor |
| *gc_ptn()* | Set cursor pattern |
| *gc_show()* | Show cursor |

## Keyboard Functions

| | |
|---|---|
| *kb_rdy()* | Check for data ready |
| *kb_read()* | Read keyboard event |
| *kb_rel()* | Release keyboard |
| *kb_repeat()* | Set keyboard Latency and Repeat times |
| *kb_ssig()* | Send signal on data ready |
| *kb_stat()* | Get Keyboard Status |

## Pointer Functions

| | |
|---|---|
| *pt_coord()* | Return pointer coordinates |
| *pt_org()* | Set pointer origin |
| *pt_pos()* | Position the pointer |
| *pt_rel()* | Release pointer device |
| *pt_ssig()* | Send signal on pointer change |

## Region Functions

| | |
|---|---|
| *rg_creat()* | Create region |
| *rg_del()* | Delete region |
| *rg_diff()* | Create region from difference of two regions |
| *rg_isect()* | Create region from intersection of two regions |
| *rg_move()* | Move region |
| *rg_union()* | Create region from union of two regions |
| *rg_xor()* | Create region from "exclusive or" of two regions |

## Video Inquiry Functions

| | |
|---|---|
| *viq_cpos()* | Return relative character positions |
| *viq_dminfo()* | Return drawmap descriptor information |
| *viq_fdta()* | Return font data |
| *viq_gdta()* | Return glyph data |
| *viq_jcps()* | Return character positions for justified text |
| *viq_pntr()* | Test if pointer is in region |
| *viq_rinfo()* | Return region descriptor information |
| *viq_rloc()* | Inquire region location |
| *viq_txtl()* | Calculate length of text |

## Soundmap Functions

| | |
|---|---|
| *sc_atten()* | Set volume, balance and position of sound |
| *sd_loop()* | Set soundmap loopback points |
| *sd_mmix()* | Mix monaural to stereo |
| *sd_smix()* | Mix stereo to stereo |
| *sm_close()* | Close soundmap |
| *sm_cncl()* | Conceal error in soundmap |
| *sm_creat()* | Create soundmap |
| *sm_info()* | Get soundmap information |
| *sm_off()* | Turn off audio processor |
| *sm_out()* | Output soundmap |
| *sm_stat()* | Return current play status |

## Compact Disc Functions

| | |
|---|---|
| *gs_eof()* | Test for end-of-file |
| *gs_gfd()* | Return file descriptor |
| *gs_opt()* | Get options of path descriptor |
| *gs_path()* | Get fill pathlist of open file |
| *gs_pos()* | Return file position |
| *gs_size()* | Get size of file |
| *ss_abort()* | Abort operation in progress |
| *ss_cchan()* | Change data and audio channels |
| *ss_cdda()* | Play CD digital audio |
| *ss_cont()* | Continue play on disc drive |
| *ss_disable()* | Disable hardware control buttons on player |
| *ss_eject()* | Issue door-open command to disc drive |
| *ss_enable()* | Enable hardware control buttons on player |
| *ss_mount()* | Mount disc-by-disc number |
| *ss_opt()* | Set path descriptor options |
| *ss_pause()* | Pause the disc drive |
| *ss_play()* | Play real-time records |
| *ss_raw()* | Read raw sectors |
| *ss_readtoc()* | Read Table of Contents |
| *ss_seek()* | Move file-position pointer |
| *ss_slink()* | Link in subroutine module |
| *ss_stop()* | Stop the disc drive |

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# APPENDIX B

**A CD-I Who's Who**

The following companies are currently involved in one aspect or another of the CD-I business. While the list is not complete, it does represent many of the primary companies involved at the time of this writing.

## AUTHORING SYSTEM SUPPLIERS:

***APLIX***
4-4, Koami-Cho, Nihombashi,
Chuo-Ku, Tokyo, Japan
Phone: (81) 03-3663-3148
Fax: (81) 03-3639-5684

***CRC RESEARCH INSTITUTE, INC.***
3-6-2, Nihombashi-Honcho,
Chuo-Ku, Tokyo, Japan
Phone: (81) 03-3665-9743
Fax: (81) 03-3662-1924

***INTERACTIVE SUPPORT GROUP, INC.***
21032 Devonshire St., Suite 209
Chatworth, CA 91311
Phone: 818-709-7387
Fax: 818-709-8160

***OPTIMAGE INTERACTIVE SERVICES COMPANY L.P.***
1501 50th Street, Suite #100
West Des Moines, IA 50265-5961
Phone: 515-225-7000 or
Phone: 800-CDI-5484
Fax: 515-225-0252

***PHILIPS, IMS***
Building SFH-6
Kastanjelaan
P.O. Box 80002
5600 JB Eindhoven
The Netherlands
Phone: (40) 73-6228

***SCRIPT SYSTEMS, INC.***
P.O. Box 39
Ferncliff Road #1
Mohawk, NY 13407
Phone: 315-866-7197
Pax: 315-866-7206

## Player Manufacturers:

***GOLDSTAR***

20, Yoido-Dong, Youngdungpo-Gu,
Seoul 150-721, Korea
Phone: (82) 02-787-3411
Fax: (82) 02-787-3400

***KYOCERA CORPORATION***

Yohga Office
2-14-9, Tamagawadai, Setagaya-Ku,
Tokyo, Japan
Phone: (81) 03-3708-3111
Fax: (81) 03-3708-3867

***MATSUSHITA ELECTRIC INDUSTRIAL CO, LTD.***

1-15, Matsuba-Cho, Kadoma,
Osaka, Japan
Phone: (81) 06-906-7732
Fax: (81) 06-905-4062

***MICROBOARDS, INC.***

Head Office:
31-8, Takasecho,
Funabashi-Shi, Chiba, Japan
Phone: (81) 0474-37-9811
Fax: (81) 0474-37-9819

San Francisco Office:
1230 Oakmead Parkway, Suite 208,
Sunnyvale, CA 94086
Phone: 408-73-3994
Fax: 408-737-3997

***PHILIPS CONSUMER ELECTRONICS***
One Philips Drive
P.O. Box 14810
Knoxville, TN 37914-1810
Phone: 615-521-4638
Fax: 615-521-3210

***PIONEER ELECTRONIC CORPORATION***
Tokorozawa R&D Laboratory
2610 Hanazono 4-Chome, Tokorozawa-Shi,
Saitama, Japan
Phone: (81) 0429-42-1151
Fax: (81) 0429-43-0395

***SANYO ELECTRIC COMPANY, LTD.***
180 Ohmori, Anpachi-Cho,
Anpachi-Gun, Gifu, Japan
Phone: (81) 0584-64-3996
Fax: (81) 0584-64-4754

***SONY CORPORATION***
6-7-35, Kitashinagawa,
Shinagawa-ku, Tokyo, Japan
Phone: (81) 03-3458-5961
Fax: (81) 03-3458-7919

***VICTOR COMPANY OF JAPAN, LTD. (JVC)***
1766-1, Shimotsuruma,
Yamato, Kanagawa 242, Japan
Phone: (81) 0462-78-1702
Fax: (81) 0462-78-1766

***YAMAHA CORPORATION***
10-1 Nakazawa-Cho,
Hamamatsu 430, Japan
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Fax: (81) 0534-74-5849

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***CAPITOL DISC INTERACTIVE***
2121 Wisconsin Avenue NW
Washington, D.C. 20007
Phone: 202-965-7800
Fax: 202-625-0210

***CSK RESEARCH INSTITUTE***
2-5-1, Suwa, Tama-Shi,
Tokyo 206, Japan
Phone: (81) 0423-75-1271
Fax: (81) 0423-75-0095

***DENSHI MEDIA SERVICES COMPANY, LTD.***
5F Toppan Yaesu Bldg., 2-7, Yaesu 2-Chome, Chuo-Ku,
Tokyo 104, Japan
Phone: (81) 03-3276-8070
Fax: (81) 03-3275-9510

***GTE IMAGITREK***
2385 Camino Vida Roble, Suite 200-A
Carlsbad, CA 92008
Phone: 619-431-8801
Fax: 619-431-8755

***INTERACTIVE PRODUCTION ASSOCIATES***
3310 Airport Ave.
Santa Monica, CA 90405
Phone: 213-390-9466

***JAPAN INTERACTIVE MEDIA, INC.***
Hitokuchizaka Bldg., 4-3-31, Kudankita,
Chiyoda-Ku, Tokyo 102, Japan
Phone: (81) 03-3221-3088
Fax: (81) 03-3221-3086

***MICROMALL, INC.***
1900 NW 114th Street
Des Moines, IA 50325-7077
Phone: 515-224-1929
Fax: 515-224-1352

***MICROWARE SYSTEMS CORPORATION***
1900 N.W. 114th St.
Des Moines, IA 50325-7077
Phone: 515-224-1929
Fax: 515-224-1352

***MICROWARE SYSTEMS K.K.***
17-3, Sotokanda 2-Chome, Chiyoda-Ku,
Tokyo, Japan
Phone: (81) 03-3257-9000
Fax: (81) 03-3257-9200

***NEW MEDIA SYSTEMS***
12 Oval Road
London NW1 7DH
England
Phone: (44) 71-482-5258
Fax: (44) 71-482-4957

***NIPPON STEEL COMPANY***
1 Yahata-Cho, Chikkou,
Sakai, Osaka, Japan
Phone: (81) 0722-33-1171
Fax: (81) 0722-33-1114

***ON LINE COMPUTER SYSTEMS INC.***
20251 Century Blvd.
Germantown, MD 20874
Phone: 301-428-3700
Phone: 800-922-9204

***PHILIPS INTERACTIVE MEDIA OF AMERICA***
11111 Santa Monica Blvd.
Los Angeles, CA 90025
Phone: 213-473-4050
Fax: 213-477-4953

***QUERY, INC.***
Tanaka 10th Bldg., 3-54-5, Wada,
Suginami-Ku, Tokyo, Japan
Phone: (81) 03-3311-9130
Fax: (81) 03-3313-1309

***RICOH EDUCATIONAL EQUIPMENT***
Nomurashouken Bldg., 1-14-16, Shibuya
Shibuya-Ku, Tokyo 150, Japan
Phone: (81) 03-3498-4151
Fax: (81) 03-3409-2570

***TOPPAN***
Toppan Bldg., 5-1, Taito 1-Chome,
Taito-Ku, Tokyo, Japan
Phone: (81) 03-3835-6631
Fax: (81) 03-5688-8028

***VISTEC CO., LTD.***
2-14-3, Taishido, Setagaya-Ku,
Tokyo, Japan
Phone: (81) 03-3487-8211
Fax: (81) 03-3487-8261

## Disc Replication:

***3M***

3M Optical Recording Dept.
Building 223-5S-01, 3M Center
St. Paul, MN 55144-1000
Phone: 612-736-3274
Fax: 612-733-0158

***DENON / NIPPON COLUMBIA***

14-14, 4-Chome, Akasaka, Minato-Ku,
Tokyo 107-11, Japan
Phone: (81) 03-3584-8111
Fax: (81) 03-3586-1859

***DENON DIGITAL INDUSTRIES***

1380 Monticello Road
Madison, GA 30650
Phone: 404-342-3425
Fax: 404-342-0637

***DMI PDO***

1409 Foulk Road
Suite 202
Wilmington, DE 19803
Phone: 302-479-2500
Fax: 302-479-2527

***NIMBUS INFORMATION SYSTEMS INC.***

P.O. Box 7305
Charlottesville, VA 22906
Phone: 804-985-1100
Fax: 804-985-4692

***PHILIPS AND DU PONT OPTICAL CO.***
Klusriede 26, D-3012 Langenhagen 1
Germany
Phone: (49) 511-73060
Fax: (49) 511-731802

***SANYO ELECTRIC COMPANY, LTD.***
180 Ohmori, Anpachi-Cho,
Anpachi-Gun, Gifu, Japan
Phone: (81) 0584-64-4974
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***VICTOR COMPANY OF JAPAN, LTD. (JVC)***
1766-1, Shimotsuruma,
Yamato, Kanagawa 242, Japan
Phone: (81) 0462-75-1111

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# GLOSSARY

## A Collection of CD-I Terms

**Adaptive Delta Pulse Code Modulation**
A technique for converting analog audio into digital audio. Delta modulation assumes close correlation between successive samples. It cannot accurately express large transients in an audio signal because the correlation between successive samples is too low. Adaptive delta pulse code modulation is a variant of delta modulation in which the quantization steps are adapted to the dynamic amplitude variation. This adaptation can include a temporary switch to PCM. See Pulse Code Modulation.

**ADPCM** (See Adaptive Delta Pulse Code Modulation.)

**ADPCM Decoder**
Converts the CD-I audio sector encoded data to 16-bit PCM encoded audio.

**Album Identifier**
Field of the File Structure Volume Descriptor identifying the set of discs (or album) to which the volume belongs.

**Album Set Sequence Number**
Specifies the relative sequence number of a disc in the album to which it belongs.

**Audio Mixing Control Unit**
Consists of four attenuators between the two audio inputs and

two audio outputs of the unit. The attenuation is controlled in steps of one decibel.

**Audio Processor**
Converts digitally coded audio information into the left and right analog outputs.

**Audio Sector**
A sector in which the data field contains audio data.

**Audio Sector Interleaving**
A method of recording audio sectors with a fixed duty cycle on the disc, according to the average data rate required.

**Audio Track**
A CD-DA track with digital audio samples encoded as 16-bit numbers.

**Backdrop**
The background image plane that becomes visible when all or parts of all other planes are made transparent.

**Base Case System**
The minimum characteristics always offered by any CD-I system.

**CD-DA Track**
A track on a Compact Disc containing audio information encoded according to the CD-Digital Audio specification.

**CDFM** (See Compact Disc File Manager.)

**CDFM Device Driver**
The lowest level of system software that provides the interface between the CDFM and the CD controller.

**CD-RTOS**
Compact Disc Real-Time Operating System. The name of the operating system used in CD-I players.

**CD-RTOS Kernel**
The nucleus of CD-RTOS, which is responsible for service request processing, memory management, system initialization, multi-tasking, input/output management and exception and interrupt processing.

**CLUT** (See Color Look-Up Table.)

**Color Key**
A CLUT image may be compared on an RGB basis, pixel by pixel, to a color key. The value of the comparison (true or false) may be used to effect the image transparency.

**Color Look-Up Table**
A table containing all the colors that may be used in a particular picture. Each entry provides an RGB value. The picture may then be encoded using the table entry addresses rather than the direct RGB values.

**Compact Disc File Manager**
A CD-RTOS file manager that handles I/O requests for the Compact Disc drive and the audio decoder. Provides random access to disc files at the byte level through system calls.

**Compact Disc Real-Time Operating System**
The name of the operating system used in CD-I players.

**Compression**
A technique in which the amount of information used to present a specific image is reduced by eliminating redundant or unnecessary information.

**Configuration Status Descriptor**
A list of Device Status Descriptors that describes the hardware configuration of a particular CD-I system.

**Cursor Plane**
A small graphical image plane that can be moved around the dis-

play or made invisible as required. It can be positioned at any position over the other planes.

**Cut**

A visual effect in which an image is caused to appear suddenly, usually to replace a previous image.

**DCP** (See Display Control Program.)

**Delta YUV**

"YUV" is a picture-coding technique in which each pixel is represented by a measure of its luminance (brightness: Y) and chrominance (color: U and V) components. Delta YUV is a compression technique in which the differences between successive Y, U and V values are encoded rather than the absolute quantities.

**Device Status Descriptor**

A descriptor that lists the capabilities or features of a device. See Configuration Status Descriptor.

**Directory Files**

Special files that "contain" other files. Directories are often referred to as "folders" and used to organize similar types of files.

**Disc Label**

The information in the first track of a CD-I disc concerning the disc type and format, the status of the disc as a single entity or part of an album, the data size and the name of the primary application on the disc.

**Display Control Program**

A set of command codes that are interpreted by the display hardware during either the horizontal or vertical retrace periods. The codes can be used to perform a variety of functions: definition of background colors, entries for color look-up tables, display parameters, etc.

**Display Line Start Pointers**
Indicates where in memory the display shall start on a line-by-line basis. If there is no display line start point for a given line, the line will start at a memory address directly after the end of the previous line.

**Dissolve**
The simultaneous fade-in of one image and fade-out of another.

**Double Resolution**
A double-resolution picture has twice as many pixels as a normal-resolution picture in the horizontal direction, but the same number in the vertical direction.

**Drawmap**
A block of memory allocated by the User Communications Manager to store image data.

**DSD** (See Device Status Descriptor.)

**DYUV** (See Delta YUV.)

**End-of-Record bit**
A bit in the submode byte of the subheader that is set to one for the last sector of a real time or non-real time record.

**EOR-bit** (See End-Of-Record bit.)

**Fade**
A gradual decrease (fade-out) or increase (fade-in) in the brightness level of an image.

**Field Control Table**
A one-dimensional array of Display Control instructions that are carried out before the start of each field.

**File**
A collection of logically-related records identifiable in a directory by a unique name.

**File Manager**

A CD-RTOS module that processes raw data streams for use by a class of similar devices.

**High Resolution**

A high-resolution picture has twice as many pixels as a normal-resolution picture in both the horizontal and vertical directions.

**Image Coding Method**

One of a number of ways of coding the RGB pixel values of an image, usually with the aim of compressing the amount of data needed to represent the image. The specified methods are RGB555, DYUV, QHY, CLUT and Runlength CLUT.

**Image Mixing**

The images of two superimposed planes, A and B, may be intermixed after decoding to RGB on a pixel basis. The resultant image is equal to the sum of the two images, each multiplied by its own Image Contribution Factor.

**Image Plane**

A displayed image may be formed by the superimposition of a number of component pictures. Each of these constitutes an image plane.

**Kernel**

The heart of an operating system that is responsible for most system-related functions.

**Line Control Table**

A two-dimensional array of Display Control instructions, each row of which is associated with a displayed line.

**Matte**

An area of the display used to control the transparency of image planes.

**Mode 2**

One of the two physical sector formats defined for CD-ROM. CD-I sector specification further describes two types of "Mode 2" sectors according to their "submode" contents: Form 1 sectors incorporate EDC/ECC error detection and correction fields. Form 2 sectors incorporate an auxiliary data field instead of EDC/ECC error detection and correction fields.

**Mouse**

A palm-sized unit equipped, typically, with two control buttons and used to manipulate a graphic cursor for controlling an application. Functions are invoked by moving the mouse to designated areas and pressing one of the buttons.

**MPU**

Microprocessing unit.

**Non-Volatile RAM**

Special memory able to retain its contents when the main power to the unit is removed.

**Non-Volatile RAM File Manager**

The file manager that is used to maintain the contents of the non-volatile RAM in the CD-I system.

**Normal Resolution**

A displayed image may be regarded as a rectangular array of pixels. The resolution refers to the number of pixels in the horizontal and vertical directions. A normal-resolution picture is a picture with the lowest resolution defined in the CD-I system and reflects the resolution of present 525/625 color television sets.

**NRF** (See Non-Volatile RAM File Manager.)

**NVRAM** (See Non-Volatile RAM.)

**Overlay**
The process of superimposing image planes in a given visual image.

**PCM** (See Pulse Code Modulation.)

**Pipeman**
The Pipe File Manager. One of the file managers of CD-RTOS that supports interprocess communication through the use of "pipes."

**Pixel**
An image may be considered to be made up of a number of small units known as pixels or picture elements. A pixel is the smallest element of an image that can be manipulated or identified.

**Plane** (See Image Plane.)

**Play Control Block**
A data structure that contains the necessary information concerning the data to be accessed on the disc for the Real-Time Record Play function of the Compact Disc File Manager.

**Pulse Code Modulation**
A technique for recording analog information in digital form. The analog signal is sampled and the sampled value is quantized, i.e., represented by a fixed-length binary number. This number is then transmitted as a corresponding set of pulses.

**RAM**
Random Access Memory. (1) In computing, a memory chip used with microprocessors. Information can be both read from, and written into the memory, but the contents are lost when the power supply is removed, (2) any form of storage in which the access time for any item of data is independent of the location of the data most recently obtained, e.g. immediate access store has a random access capability but magnetic disk does not.

**Real-Time File**
A file containing at least one real-time record.

**Real-Time Record**
A logical record in a CD-I file containing audio, video, and/or computer data that must be retrieved from a CD-I disc at a precise rate.

**Real-Time Sector**
Data that has to be processed without interrupting the real-time behavior of the CD-I system.

**Record**
A logical component of a file.

**RGB**
Every color can be represented as the sum of different proportions of the three primary colors, red (R), green (G) and blue (B). In RGB encoding, every pixel is represented by its R, G and B components. These are values that, on presentation to suitable digital-to-analog converters, will give the correct voltages required by the red, green and blue guns of a cathode ray tube to produce the color of the pixel on the display screen.

**RGB 555**
A method of coding visual images as 5 bits per red, green and blue component. See also RGB.

**ROM**
Read Only Memory. In computing, a memory chip whose contents can only be read, not written. In CD-I, the CD-RTOS operating system is contained in ROM.

**Run-Length Coding**
A picture data compression technique that uses two-byte codes. The first byte identifies color and the second byte tells the decoder how many consecutive pixels are to be of this color.

**Soundmap**
A memory area allocated for storage of ADPCM audio data.

**Subheader**
The subheader field is contained in each sector and defines file number, channel number, submode and coding information.

**Submode**
The submode byte defines global attributes of the sector, for instance the nature of the data (audio, video, etc.) it contains.

**Subscreen**
A horizontal strip of an image plane extending the full width of the display screen, which may contain its own image of a different coding method to other subscreens simultaneously present. Subscreens are produced using the Display Control Program. (See Display Control Program).

**Track**
A sequence of contiguous data, the beginning, length, mode and end of which are defined in the table of contents, which is held in the Q subcode channel of the lead-in area of the disc. The two types of tracks currently defined are the CD-DA track according to the CD-DA specification and the data track according to the CD-ROM specification that is also used in CD-I. In CD-DA the length of a track is related to playing times between four seconds and 72 minutes.

**Trigger Bit**
A bit in the submode byte of the subheader that is interpreted by an application to cause synchronization of various events.

**User Communications Manager**
The CD-RTOS file manager that provides the software interface to the user-input devices and to the video processor on a CD-I player.

**Video Sector**

A CD-I sector in which the data field contains video data.

**Wipe**

The replacement of one image by another during a period of time by the motion of a boundary separating the visible parts of the two images.

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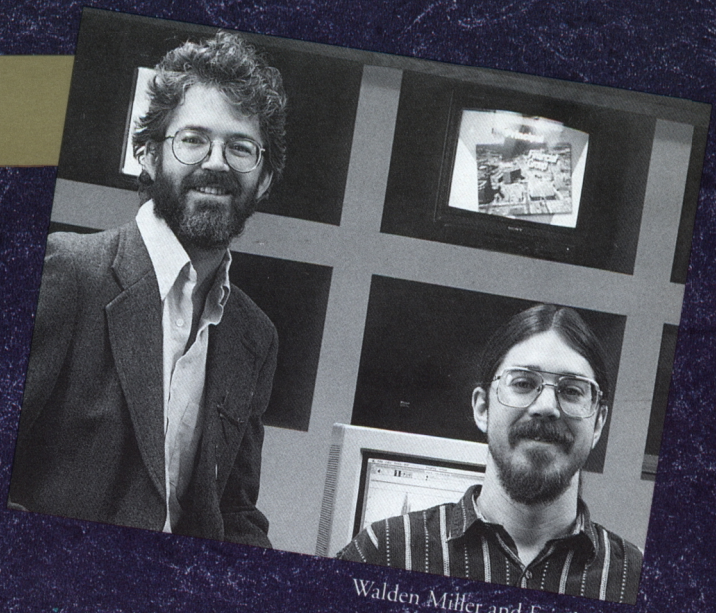
## About The Authors



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